Model for Evaluating the Competitive Power of Service Trade with Intuitionistic Fuzzy Information

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Abstract

In this paper, we investigate the multiple attribute decision making (MADM) problems for evaluating the competitive power of service trade with intuitionistic fuzzy information. A modified project method is proposed. Then, based on the traditional project method, calculation steps for evaluating the competitive power of service trade with known weight information are given. The project values between every alternative and positive ideal solution and negative ideal solution are calculated. Then, according to the concept of the project method, a relative closeness degree is defined to determine the ranking order of all alternatives. Finally, an illustrative example about risk investment is given to verify the developed approach and to demonstrate its practicality and effectiveness.

Keywords: Multiple Attribute Decision-Making (MAGM), Intuitionistic Fuzzy Information, Project Method, Competitive Power of Service Trade

1. Introduction

Nowadays service trade is growing at a speed that is even higher than the growth of trade in goods, but the situation in our country is not in coordination with the situation in the world. Therefore, analyzing and evaluating the competition of service trade the China does help us how to develop our service trade and improve the competitiveness of our service trade. By using the comparative advantage and competitive advantage theory, the competitiveness and the factors having influence on the service trade of China are both analyzed. On the one hand, an analysis is made from the speed, size, structure of China’s service trade, market share indicators, revealed comparative advantage index, Trade Competitiveness Index, as well as potential development index of China’s service trade, and the conclusions are as follows: we don’t own comparative advantage in service trade as a whole; as far as the service industries, we only own comparative advantage in tourism; though we don’t own comparative advantage in transportation, the opportunity for its development is great; we do not have comparative advantage in other commercial services and the development of it is quite unstable. Then a qualitative Analysis is made by using the theory of Porter to explain why the service trade in China is developing so slowly. The shortages of advanced and professional production factors, the lack of effective demand, the undeveloped related and supporting industry, the unequal market competitive structure, the inappropriate government intervention and protection in service trade, as well as the intense international competitive environment are the main factors influencing the development of service trade in China. Finally, some useful suggestions on how to enhance service trade competitiveness in our country efficiently are given based on these conclusions, such as exerting the comparative advantage, fostering competitive advantages in trade services, and improving the advanced factors of production, strengthening the coordination and supporting mechanisms of related and supporting industries, breaking the monopolies in the market and creating a fair competitive environment, the establishment of appropriate status of the government in market, and actively developing the service outsourcing, and etc.

Atanassov [1,2] introduced the concept of intuitionistic fuzzy set(IFS), which is a generalization of the concept of fuzzy set [3]. The intuitionistic fuzzy set has received more and more attention since its appearance. Gau and Buehrer [4] introduced the concept of vague set. But Bustince and Burillo [5] showed that vague sets are intuitionistic fuzzy sets. Chen and Tan [6] presented new techniques for handling multiple attribute fuzzy decision making problems based on vague set theory. And then Hong and Choi [7] provided another techniques for handling multiple attribute fuzzy decision making problems based on vague set theory, they provided new functions to measure the degree of accuracy in the grades of membership of each alternative with respect to a set of attribute. However, they assumed
that the degree of importance to each attribute is constant. Li [8] investigated multiple attribute
decision making with intuitionistic fuzzy information and constructed several linear programming
models to generate optimal weights for attribute. Lin [9] presented a new method for handling multiple
attribute fuzzy decision making problems, where the characteristics of the alternatives are represented
by intuitionistic fuzzy sets. The proposed method allows the degrees of satisfiability and non-
satisfiability of each alternative with respect to a set of attribute to be represented by intuitionistic
fuzzy sets, respectively. Furthermore, the proposed method allows the decision-maker to assign the
degree of membership and the degree of non-membership of the attribute to the fuzzy concept “importance.” Wang et al. [10] investigated the multiple attribute decision making (MADM) problems
for evaluating the archives websites’ performance with interval intuitionistic fuzzy information. Then,
based on the TOPSIS method, calculation steps for solving MADM problems for evaluating the
archives websites’ performance with interval intuitionistic fuzzy information are given. The weighted
Hamming distances between every alternative and positive ideal solution and negative ideal solution
are calculated. Then, according to the weighted Hamming distances, the relative closeness degree to
the positive ideal solution is calculated to rank all alternatives. Finally, an illustrative example
for evaluating the archives websites’ performance with interval intuitionistic fuzzy information is given.
Chen [11] investigated the multiple attribute decision making problems for selecting an ERP system
with intuitionistic trapezoidal fuzzy information. They utilize the intuitionistic trapezoidal fuzzy
weighted average (ITFWA) operator to aggregate the intuitionistic trapezoidal fuzzy information
corresponding to each alternative and get the overall value of the alternatives, then rank the alternatives
and select the most desirable one(s) according to the distance between the overall value of the
alternatives and ideal solution. Finally, an illustrative example about selecting an ERP system is given.
Wei[12] has investigated the problem of MADM with incompletely known information on attribute
weights to which the attribute values are given in terms of intuitionistic fuzzy numbers. To determine
the attribute weights, an optimization model based on the maximizing deviation method, by which the
attribute weights can be determined, is established. For the special situations where the information
about attribute weights is incompletely known, we establish another optimization model. By solving
this model, they get a simple and exact formula, which can be used to determine the attribute weights.
They utilize the intuitionistic fuzzy weighted averaging (IFWA) operator to aggregate the intuitionistic
fuzzy information corresponding to each alternative, and then rank the alternatives and select the most
desirable one(s) according to the score function and accuracy function. Wei[13] investigated the multiple
attribute decision making problems with intuitionistic fuzzy information, in which the information
about attribute weights is incompletely known, and the attribute values take the form of
intuitionistic fuzzy numbers. In order to get the weight vector of the attribute, they established an
optimization model based on the basic ideal of traditional grey relational analysis (GRA) method, by
which the attribute weights can be determined. Then, based on the traditional GRA method, calculation
steps for solving intuitionistic fuzzy multiple attribute decision-making problems with incompletely
known weight information are given. The degree of grey relation between every alternative and
positive ideal solution and negative ideal solution are calculated. Then, a relative relational degree is
defined to determine the ranking order of all alternatives by calculating the degree of grey relation to
both the positive-ideal solution (PIS) and negative-ideal solution (NIS) simultaneously. Finally, an
illustrative example is given to verify the developed approach and to demonstrate its practicality and
effectiveness.

The problem of the competitive power of service trade with intuitionistic fuzzy information is the
multiple attribute decision making (MADM) problems [10-24].The aim of this paper is to investigate
the MADM problems for evaluating the competitive power of service trade with intuitionistic fuzzy
information. The remainder of this paper is set out as follows. In the next section, we introduce some
basic concepts related to intuitionistic fuzzy sets. In Section 3 we introduce the MADM problem deal
with appraisal model of the competitive power of service trade with intuitionistic fuzzy information.
Then, based on the traditional project method, calculation steps for evaluating the competitive power of
service trade with known weight information are given. The project values between every alternative
and positive ideal solution and negative ideal solution are calculated. Then, according to the concept of
the project method, a relative closeness degree is defined to determine the ranking order of all
alternatives. In Section 4, an illustrative example is pointed out. In Section 5 we conclude the paper and
give some remarks.
2. Preliminaries

In the following, we introduce some basic concepts related to intuitionistic fuzzy sets.

**Definition 1.** Let $X$ be a universe of discourse, then a fuzzy set is defined as:

$$A = \{ (x, \mu_A(x)) \mid x \in X \}$$

(1)

Which is characterized by a membership function $\mu_A : X \rightarrow [0,1]$, where $\mu_A(x)$ denotes the degree of membership of the element $x$ to the set $A$ [3].

Atanassov[1-2] extended the fuzzy set to the IFS, shown as follows:

**Definition 2.** An IFS $\tilde{A}$ in $X$ is given by

$$\tilde{A} = \{ (x, \mu_A(x), \nu_A(x)) \mid x \in X \}$$

(2)

Where $\mu_A : X \rightarrow [0,1]$ and $\nu_A : X \rightarrow [0,1]$, with the condition

$$0 \leq \mu_A(x) + \nu_A(x) \leq 1, \quad \forall x \in X$$

The numbers $\mu_A(x)$ and $\nu_A(x)$ represent, respectively, the membership degree and non-membership degree of the element $x$ to the set $A$ [1,2].

**Definition 3.** For each IFS $\tilde{A}$ in $X$, if

$$\pi_A(x) = 1 - \mu_A(x) - \nu_A(x), \quad \forall x \in X.$$ 

(3)

Then $\pi_A(x)$ is called the degree of indeterminacy of $x$ to $A$ [1,2].

**Definition 4.** Let $\tilde{a} = (\mu, \nu)$ be an intuitionistic fuzzy number, a score function $S$ of an intuitionistic fuzzy value can be represented as follows [6]:

$$S(\tilde{a}) = \mu - \nu, \quad S(\tilde{a}) \in [-1,1].$$

(4)

3. Model for Evaluating the Competitive Power of Service Trade with Intuitionistic Fuzzy Information

The problem of the competitive power of service trade with intuitionistic fuzzy information is the multiple attribute decision making (MADM) problems. The aim of this section is to investigate the MADM problems for evaluating the competitive power of service trade with intuitionistic fuzzy information. Let $A = \{ A_1, A_2, \ldots, A_n \}$ be a discrete set of alternatives. Let $G = \{ G_1, G_2, \ldots, G_n \}$ be a set of attributes. The information about attribute weights is completely known. Let $\omega = (\omega_1, \omega_2, \ldots, \omega_n)$ be the weight vector of attributes, where $\omega_j \geq 0$, $j = 1,2,\ldots,n$. Suppose that

$$\tilde{R} = (\tilde{r}_{ij})_{m,n} = (\mu_{ij}, \nu_{ij})_{m,n}$$

is the intuitionistic fuzzy decision matrix, where $\mu_{ij}$ indicates the degree that the alternative $A_i$ satisfies the attribute $G_j$ given by the decision maker, $\nu_{ij}$ indicates the degree that the alternative $A_i$ doesn’t satisfy the attribute $G_j$ given by the decision maker, $\mu_{ij} \in [0,1]$, $\nu_{ij} \in [0,1]$, $\mu_{ij} + \nu_{ij} \leq 1$, $i = 1,2,\ldots,m$, $j = 1,2,\ldots,n$.

In the following, we apply the proposed model to MADM for evaluating the competitive power of service trade with intuitionistic fuzzy information.

**Step 1.** Determine the positive ideal and negative ideal solution based on intuitionistic fuzzy numbers.

$$\tilde{r}^+ = \left( (\mu_1^+, \nu_1^+), (\mu_2^+, \nu_2^+), \ldots, (\mu_n^+, \nu_n^+) \right)$$

(5)
\[ r^* = \left( \left( \mu_1^*, V_1^* \right), \left( \mu_2^*, V_2^* \right), \ldots, \left( \mu_n^*, V_n^* \right) \right) \] 

where

\[ r_j^* = \left( \mu_j^*, V_j^* \right) = \left( \max_i \mu_{ij}, \min_i V_{ij} \right), \quad j = 1, 2, \ldots, n. \]

\[ r_j^- = \left( \mu_j^-, V_j^- \right) = \left( \min_i \mu_{ij}, \max_i V_{ij} \right), \quad j = 1, 2, \ldots, n. \]

**Step 2.** Calculate the project values of each alternative from PIS and NIS using the following equation, respectively:

The project values of each alternative from PIS is given as

\[
\Pr j_{\alpha} (A_i) = \Delta \left( \sum_{j=1}^{n} w_j s(\mu_{ij}, V_{ij}) s(\mu_j^*, V_j^*) \right) / \sqrt{\sum_{j=1}^{n} \left[ w_j s(\mu_j^*, V_j^*) \right]^2}, \quad i = 1, 2, \ldots, m, \quad j = 1, 2, \ldots, n. \tag{7}
\]

Similarly, the project values of each alternative from NIS is given as

\[
\Pr j_{\alpha}^- (A_i) = \Delta \left( \sum_{j=1}^{n} w_j s(\mu_{ij}, V_{ij}) s(\mu_j^-, V_j^-) \right) / \sqrt{\sum_{j=1}^{n} \left[ w_j s(\mu_j^-, V_j^-) \right]^2}, \quad i = 1, 2, \ldots, m, \quad j = 1, 2, \ldots, n. \tag{8}
\]

**Step 3** Calculating the relative closeness degree of each alternative from PIS using the following equation,

\[
\Pr j(A_i) = \Delta \left( \frac{\Pr j_{\alpha} (A_i)}{\Pr j_{\alpha} (A_i) + \Pr j_{\alpha}^- (A_i)} \right) \tag{9}
\]

**Step 4.** Rank all the alternatives \( A_i (i = 1, 2, \ldots, m) \) and select the best one(s) in accordance with \( \Pr j(A_i) (i = 1, 2, \ldots, m) \). If any alternative has the highest \( \Pr j(A_i) \) value, then, it is the most important alternative.

**Step 5.** End.

4. **Numerical Example**

Nowadays service trade is growing at a speed that is even higher than the growth of trade in goods, but the situation in our country is not in coordination with the situation in the world. Therefore, analyzing and evaluating the competition of service trade the China does help us how to develop our service trade and improve the competitiveness of our service trade. By using the comparative advantage and competitive advantage theory, the competitiveness and the factors having influence on the service trade of China are both analyzed. In this section, we present an empirical case study of evaluating competitive power of service trade with intuitionistic fuzzy information. Let us suppose there is a risk investment company, which wants to invest a sum of money in the best option. There is a panel with five possible cities \( A_i (i = 1, 2, 3, 4, 5) \) to invest the money. The team of experts must take a decision according to the following four attributes: ①G1 is the market share; ②G2 is the revealed comparative advantage index; ③G3 is the competitive advantage index; ④G4 is the development potentiality index. The five possible cities \( A_i (i = 1, 2, \ldots, 5) \) are to be evaluated using the
intuitionistic fuzzy information by the decision maker under the above four attributes, as listed in the following matrix.

\[
\bar{R} = \begin{bmatrix}
(0.6,0.4) & (0.3,0.5) & (0.1,0.8) & (0.3,0.6) \\
(0.3,0.7) & (0.7,0.2) & (0.3,0.6) & (0.3,0.4) \\
(0.5,0.4) & (0.4,0.5) & (0.6,0.2) & (0.1,0.4) \\
(0.8,0.1) & (0.5,0.4) & (0.3,0.4) & (0.2,0.6) \\
(0.5,0.4) & (0.4,0.3) & (0.6,0.1) & (0.9,0.1)
\end{bmatrix}
\]

And the weighting vector of \( G_1, G_2, G_3 \) and \( G_4 \) is as follows:

\[ w = (0.20, 0.10, 0.30, 0.40) \]

Then, we utilize the approach developed to get the most desirable cities.

**Step 1.** Determine the positive ideal and negative ideal solution

\[
\bar{r}^+ = \left( (0.8,0.1) \quad (0.7,0.2) \quad (0.6,0.1) \quad (0.9,0.1) \right) \\
\bar{r}^- = \left( (0.3,0.7) \quad (0.3,0.5) \quad (0.1,0.8) \quad (0.1,0.6) \right)
\]

**Step 2.** Calculate the project values of every city and TLPIS and TLNIS

\[
\Prj_{A_1} (A_1) = -0.1703, \Prj_{A_1} (A_2) = -0.0913 \\
\Prj_{A_1} (A_3) = -0.0472, \Prj_{A_1} (A_4) = -0.0929 \\
\Prj_{A_1} (A_5) = 0.3344, \Prj_{A_1} (A_1) = 0.2166 \\
\Prj_{A_1} (A_2) = 0.1071, \Prj_{A_1} (A_3) = -0.0086 \\
\Prj_{A_1} (A_4) = 0.0892, \Prj_{A_1} (A_4) = -0.3227
\]

**Step 3.** Calculate the relative closeness degree of each city from PIS

\[
\Prj(A_1) = -3.6808, \Prj(A_2) = -5.7612 \\
\Prj(A_3) = 0.8455, \Prj(A_4) = 25.5766 \\
\Prj(A_4) = 28.7067
\]

**Step 4.** According to the relative closeness degree, the ranking order of the five cities is:

\( A_5 > A_4 > A_3 > A_1 > A_2 \), and thus the most desirable city is \( A_5 \).

**5. Conclusion**

The problem of the competitive power of service trade with intuitionistic fuzzy information is the multiple attribute decision making (MADM) problems. The aim of this paper is to investigate the MADM problems for evaluating the competitive power of service trade with intuitionistic fuzzy information. So, in this paper, we investigate the multiple attribute decision making (MADM)
problems for evaluating the competitive power of service trade with intuitionistic fuzzy information. A modified project method is proposed. Then, based on the traditional project method, calculation steps for evaluating the competitive power of service trade with known weight information are given. The project values between every alternative and positive ideal solution and negative ideal solution are calculated. Then, according to the concept of the project method, a relative closeness degree is defined to determine the ranking order of all alternatives. Finally, an illustrative example about risk investment is given to verify the developed approach and to demonstrate its practicality and effectiveness.

6. References