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Research Article

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A Fuzzy-ANP Based comprehensive evaluation method for assessing the regional investment environment: From the perspective of attracting investment

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ABSTRACT

As an important measure to promote the benign development of regional economy, attracting investment has got extensive attentions from governments at all levels.However, it is still an unsolved problem to conduct a comprehensive assessment on the regional investment environment in the perspective of attracting investment. Therefore, this paper presents an comprehensive evaluation method based on Fuzzy Analytic Network Process(fuzzy ANP) which has a strong theoretical and practical significance.This method is scientific and feasible,specifically,compared with previous work,the method proposed in this article can effectively analyze the complex relationship about Interdependence and feedback between systemic factors and this advantage could be considered as a core innovation in this research.

Key words: attracting investment, investment environment, Fuzzy ANP, evaluation

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INTRODUCTION

In recent years, governments at all levels in china had attached great importance to attracting investment, and a series of preferential policies were enacted. However, in order to attract external quality capital and promote regional development, relying solely on preferential policies is clearly not enough,the most important thing for our government is to insist on scientific development and improve the regional investment environment.To help our government managers scientifically evaluate the regional investment environment, experts and scholars have conducted a preliminary exploration and put forward a series of evaluation methods for the regional investment environment. For instance,by using factor analysis and cluster analysis, YuTing(2010) made a quantitative analysis on the investment environment of 30 cities in central China[1].Based on the principal component analysis, Wang Bo (2010) ranked the investment environment of 19 major cities in China[2].Li Xi yuan et al. (2012) carried on a empirical analysis by using questionnaire data from Hong Kong, Macao -funded enterprises, then the principal component analysis method is used to make a comprehensive assessment on the investment environment of 7cities in Pearl River Delta and find out the influence factors[3]. By using the method of AHP, Ma jin (2011) provided a integrated appraisal on the investment environment of a city[4]. In a Taiwanese manufacturer's perspective, Lu /Yang(2007) applied the method of structural equation modeling in comprehensive evaluation of the investment environment in international logistics zones [5]. Based on the neutral cross DEA, Huang Meiying (2012) had a relative efficiency analysis on the investment environment of 9 coastal cities, however, it is a pity that this method is still obvious deficiencies in the mechanism,therefore the reliability of the conclusion remains to be further tested[6].

Conclusions As a result, we draw the following points: (1) In the process of the regional investment environment evaluation, the regional characteristics should be fully reflected. (2) The existing evaluation methods are not doing well in fully depicting the the complex relationship about Interdependence and feedback between each indicator. (3) The uncertainty and fuzziness didn't get enough attention during the process of expert judgment. In consideration of the problem existing in the investment environment evaluation, on the basis of index system building,this article makes a assessment on the capacity of attracting investment,and puts forward a comprehensive evaluation method which based on FANP.

1. Brief introduction of FANP

ANP(Analytic Network Process) is a multi-criteria decision-making method which based on AHP(Analytic Hierarchy Process) and it is mainly used to deal with complex decision problems, professor Saaty ,a famous operational research expert of USA ,put forward it in 1966.Compared with AHP, ANP can deal with the relationship about Interdependence and feedback between complicated factors more efficiently. What is more, since the hierarchy is not severely limited in ANP, this method has attracted considerable attention of specialists and scholars and it has been applied in many fields[7-11].Nevertheless,in consideration of the uncertainty of decision-making hierarchies and the relevance between attributes in a complex decision problem[12], many researchers combined Fuzzy set theory with Analytic network process and put forward a more practical method named Fuzzy-ANP to reduce the uncertainty of subjective judgment by experts.Since this method is proposed, it has gained recognition by many scholars , and it has been widely used in a large number of projects.For instance, Onut et al.(2011) used a fuzzy-ANP-based approach in container port selection[13].Yüksel/Dağdeviren(2009) combined BSC(balanced score card) with Fuzzy-ANP to measure the enterprise development level, then proved the scientificity and rationality of this method by an example[14].Tang Xiaoli (2007) applied the method of Fuzzy-ANP in large engineering project risk evaluation[15].

2. Construction of evaluation index system

According to the key elements that discerned by article[16],we could construct an evaluation index system of investment environment based on the relationship between elements. See figure 1 below.

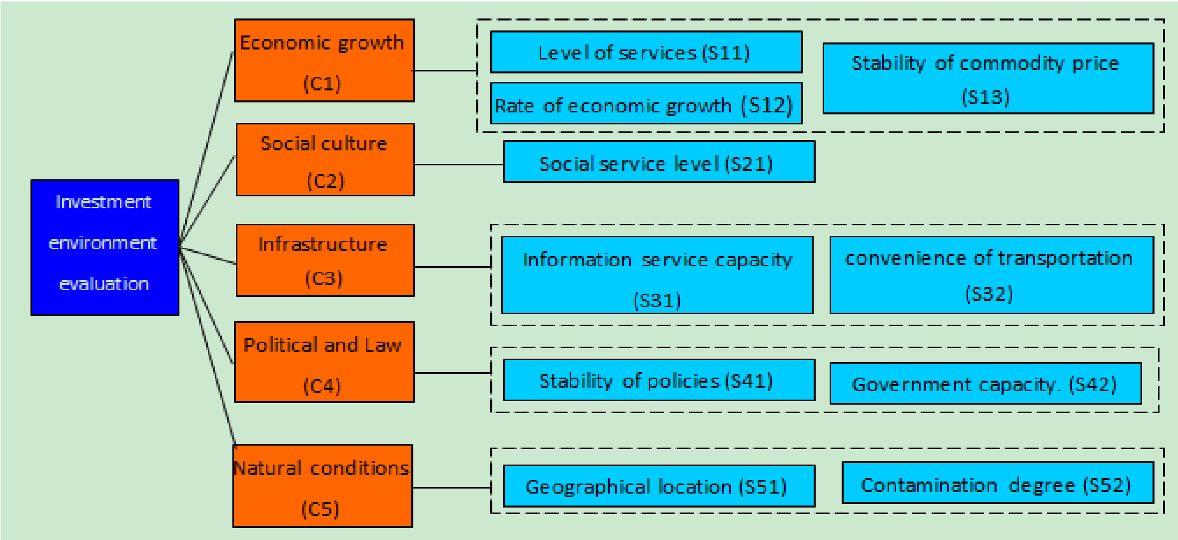

Figure1. The index system of Regional investment environment evaluation

As figure 1 shows, economic growth, social culture, infrastructure, political and law, natural conditionsare regarded as the evaluation criteria and denoted by $C1, C2, \cdots, C5$. Each evaluation criterion is reflected by several indicators. C1 is reflected by the level of services(S11, measured by the added value of the tertiary industry divided by GDP),the rate of economic growth(S12,measured by annual rate of growth of GDP),the stability of commodity price(S13,measured by inflation rate). C2 is reflected by the Social service level(S21,the proportion of social service employees/ city construction and maintaining funds per one person/ number of physicians per ten thousands person/ medical insurance income). C3 is reflected by the information service capacity(S31,mainly measured by the number of Internet users) and the convenience of transportation(S32,road area per citizen/ Mileage of highway (2 class above))/ the density of highway network). C4 is mainly measured by the stability of policies(S41,the consistency of governments policies) and the government capacity(S42,management efficiency/ treatment rate of cases/ International tourism income/ financial growth rate). C5 is measured by the geographical location (S51) and the contamination degree ((S52, industrial waste gas emissions/ output of solid wastes/ discharge of industrial wastewater).

3. Specific steps of the method

Based on the analysis above, the specific steps of a Fuzzy-ANP based evaluation method is given below.
Step 1: Build the network structure of ANP. Asfigure 2 shows, combined with the index system above and the complex relationship between indexes(See table 1below), a ANP network structure that based on evaluation object could be constructed.

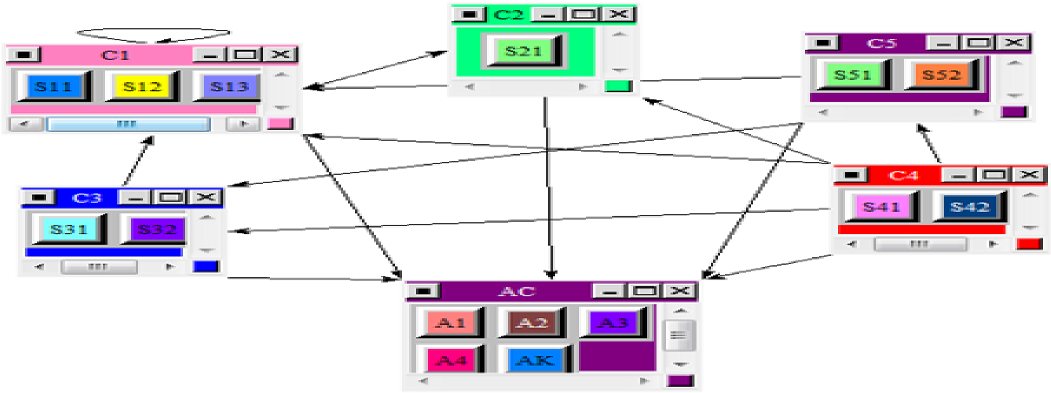

Figure 2.The ANP network structure of regional investment environment evaluation

Table 1.The dominance relationship between indexes in figure 2

The dominance relationship between all indexes	
$S11 \to S12$	$S42 \to S12$
$S13 \to S12$	$S42 \to S13$
$S11 \leftrightarrow S21$	$S42 \to S21$
$S32 \to S11$	$S42 \to S31$
$S32 \to S12$	$S51 \to S11$
$S41 \to S11$	$S51 \to S12$
$S41 \to S12$	$S51 \to S32$
$S41 \to S13$	$S52 \to S12$
$S42 \to S11$	$S42 \to S52$

Where,X $\to$ Y indicates that X dominates Y

As we see from figure 2, the ANP structure is composed of factor sets $C1, C2, \cdots, C5$ and solution sets AC($A1, A2, \cdots, AK$,K stands for the number of solution sets). The indexes inside $C1, C2, \cdots, C5$ are (S11, S12, S13), S21, (S31, S32), (S41,S42), (S51,S52). Besides, the curved arrows indicate the internal interdependent relationship between factors in a particular factor set .

Step 2: Ask experts to make a pairwise comparison,then build a comparison and judgment matrix.
Using positive triangular fuzzy number (l, m, u), this article build a judgment matrix in regard to the interrelationship between element sets. In order to reduce the fuzziness of subjective judgment, this article will take fuzzy semantic variables which denoted by positive triangular fuzzy number (l_{ij}, m_{ij}, u_{ij}) as a replacement for specific data to measure the importance of factors. The value of experts scoring will be divided into six grades, they are { no difference , equally important, slightly more important, quite important, very important, extremely important}. As table 2 shows, the relative importance of evaluation indexes is reflected by the fuzzy semantic scale given below[11].

Table 2.Triangular fuzzy number –based judgment scale

Influence degree	Triangular fuzzy number	Symmetric triangular fuzzy number
no difference	(1,1,1)	(1,1,1)
equally important	(1/2,1,3/2)	(2/3,1,2)
slightly more important	(1,3/2,2)	(1/2,2/3,1)
quite important	(3/2,2,5/2)	(2/5,1/2,2/3)
very important	(2,5/2,3)	(1/3,2/5,1/2)
extremely important	(5/2,3,7/2)	(2/7,1/3,2/5)

The Delphi method is applied to get the effect degree between factors and a fuzzy judgement matrix is constructed:

$$R = \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1n} \\ r_{21} & r_{22} & \cdots & r_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ r_{m1} & _{m2} & \cdots & r_{mn} \end{bmatrix} (1)$$

Step 3: Determine the value of fuzzy degree and calculate weights

Referring to the extent analysis method which put forward by Chang(1992,1996)[17-18] , this article used weight vectors to evaluate the relationship between criterion sets and index sets in a hierarchical structure of network. The advantage of this method is that it not only used the the concept of fuzzy number evaluation but also solved the problem of inconsistent ranking caused by overlapped fuzzy numbers during the process of using fuzzy numbers to evaluate index weight[19].

Taking the effect degree of a certain indicator $S1i(i = 1, 2, 3)$ in factor set C_1 as the sub-criterion, judging the importance of indicators which are subordinate to criterion C_1 . Specific steps are described as below:

(1)Calculate the comprehensive fuzzy value φ_{1i} of indicator $S1i(i = 1, 2, 3)$:

$$\varphi_{1i} = \sum_{j=1}^{3} M_{ij} \otimes \left[\sum_{i=1}^{3} \sum_{j=1}^{3} M_{ij} \right]^{-1} (i = 1, 2, 3)(j = 1, 2, 3) \quad (2)$$

Where $\sum_{j=1}^{3} M_{ij}$ and $\left[\sum_{i=1}^{3} \sum_{j=1}^{3} M_{ij} \right]^{-1}$ are defined as formulas (3) and (4) below.

$$\sum_{j=1}^{3} M_{ij} = \left(\sum_{j=1}^{3} l_{ij}, \sum_{j=1}^{3} m_{ij}, \sum_{j=1}^{3} u_{ij} \right) (i = 1, 2, 3)(j = 1, 2, 3) \quad (3)$$

$$\left[\sum_{i=1}^{3} \sum_{j=1}^{3} M_{ij} \right]^{-1} = \left(\frac{1}{\sum_{i=1}^{3} u_{ij}}, \frac{1}{\sum_{i=1}^{3} m_{ij}}, \frac{1}{\sum_{i=1}^{3} l_{ij}} \right) \quad (4)$$

(2) Calculate the possibility degree of $\varphi_{1i} \ge \varphi_{1k}$:

$$V(\varphi_{1i} \ge \varphi_{1k}) = \begin{cases} 1 & (m_{ij}^{1i} \ge m_{ij}^{1k}) \\ \dfrac{u_{ij}^{1i} - l_{ij}^{1k}}{u_{ij}^{1i} - l_{ij}^{1k} + m_{ij}^{1k} - m_{ij}^{1i}} & (m_{ij}^{1i} < m_{ij}^{1k}, l_{ij}^{1k} \le u_{ij}^{1i}) \\ 0 & \text{(else)} \end{cases} \quad (5)$$

Where $i = 1, 2, 3; k = 1, 2, 3 \,\&\, k \ne i; j = 1, 2, 3$.

(3) Calculatethe possibility of $S1i(i = 1, 2, 3)$ in C_1 is more important than other elements, assume that:

$$d(S1i) = \min V(\varphi_{1i} \ge \varphi_{1k}, \varphi_{1m}) \quad (6)$$

Where $i = 1, 2, 3; k = 1, 2, 3 \,\&\, k \ne i; m = 1, 2, 3 \,\&\, k \ne i \ne m$

Thus, the initial weight vector of evaluation indicators which are subordinate to criterion C_1 can be denoted as:

$$W_1^{(1i)} = [d(S11), d(S12), d(S13)]^T . \quad (7)$$

Via normalization, we get the normalized weight vector:

$$W_1^{(1i)\prime} = [d'(S11), d'(S12), d'(S13)]^T \quad (8)$$

According to formula (8) in step (3),via a N-cycles loop computation we can get the local weight vector of supermatrix $(W_1^{(1i)'},\ldots,W_3^{(1i)'})$. Based on the weight vector, a submatrix W'_{11} of super matrix is obtained. Similarly,we can get other block matrixes.

Step4: Construct the evaluation supermatrix of regional investment environment and calculate the limit.
Based on the index weight vector we obtained in step 3,a supermatirx (M') could be constructed to reflect the degree of indicators' influence on the criterion which they belong to.

$$M' = \begin{bmatrix} W'_{11} & W'_{12} & \cdots & W'_{16} \\ W'_{21} & W'_{22} & \cdots & W'_{26} \\ \cdots & \cdots & \cdots & \cdots \\ W'_{61} & W'_{62} & \cdots & W'_{66} \end{bmatrix} \quad (9)$$

By making a pairwise comparison between every two indexes in factor sets $C1,\ldots,C5$ and solution sets AC ,we get a judgement matrix. Then , via normalization, a weighted matrix could be obtained.

$$M = \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{16} \\ a_{21} & a_{22} & \cdots & a_{26} \\ \cdots & \cdots & \cdots & \cdots \\ a_{61} & a_{62} & \cdots & a_{66} \end{bmatrix} \quad (10)$$

Given that the possibility of supermatrix (M') is not column random, we should multiply the indexes in weighted matrix (M) by corresponding block matrixes in supermatix (M'). Thus a weighted supermatrix (M'') is obtained.

$$M'' = \begin{bmatrix} a_{11}W'_{11} & a_{12}W'_{12} & \cdots & a_{16}W'_{16} \\ a_{21}W'_{21} & a_{22}W'_{22} & \cdots & a_{26}W'_{26} \\ \cdots & \cdots & \cdots & \cdots \\ a_{61}W'_{61} & a_{62}W'_{62} & \cdots & a_{66}W'_{66} \end{bmatrix} \quad (11)$$

Step 5: Calculate the limit of supermatrix and find out the priorities of solutions.
Defining $M''' = \lim_{n\to\infty}(M'')^n$ as the limit of the weighted supermatrix ($n \to \infty$),we can get the limit supermatrix (M''') to reflect the comprehensive relationship between indexes. Then, based on these limit weights we can get the corresponding solutions' limit ranking weights. Finally, according to the weight values we get before, the priorities of solutions could be obtained.

CONCLUSION

It has become a focus of attention of governments at all levels to improve the regional investment environment and change the economic growth mode, to strengthen the connotative development and insist on scientific development. However,in the perspective of investment invitation, there is no ideal evaluation method in academic community to make a comprehensive evaluation of regional investment environment by far. Based on the description of correlated theory and construction of evaluation index system, this article applied a fuzzy-ANP-based approach to evaluate the regional investment environment, and the proposed method is feasible in theory and well applicablein practice.

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