Location Decision Use the Flexible AHP to Consider the Uncertainty Criteria

選擇地點使用彈性 AHP 來考量不確定準則

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Abstract

The case study presented a better method to select an optimum location; it is a hybrid technology to evaluate the certainty or uncertainty variables. Astute manager would face the several dynamic or constant variables when the energy price rises in the period, while we can utilize the analytic hierarchy process (AHP) and the fuzzy extended AHP (FEAHP) to solve related problems. Any area environment has some huge change in the economic inflation; such as the income will reduce, the expense opposite to increase, the market will decline, the crime rate will rise, the social security will worsen, and the population must naturally move out and so on. Therefore, the related variables must change along with the economic environmental change. The paper used the hybrid AHP style to choice the best location. Sequentially, the optimum location can possess the best competitive advantage in the future. This paper offer to YON DON ENTERPRISE CO., LTD making for expanding the factory buildings as based on consideration, there are pertain about some uncertainty variables to face the impact of industry competition.

Keywords: Location decision、AHP、FEAHP、MOP、LP、Economic inflation

摘要

本研究提出選擇地點的方法，是在確定與不確定變數中混合評估技術。使用層級分析法和模糊擴展層級分析法，在能源價格高漲時候，敏感面對各種動態與固定變數，綜合評估不同地點指數。在任何地區性環境都會產生巨大改變；如收入會減少、支出反而增加、市場會萎縮、犯罪率會升高、社會安全自然惡化、和人口會外流等變數。相關變數會隨著經濟環境變化而改變。本論文是採用混合式 AHP，客觀選擇最佳地點，保證未來能擁有最有利競爭優勢。提供亞達企業有限公司做為擴廠規畫考量依據，涵蓋相關不確定變數，

避免未來產業競爭的衝擊。

關鍵字：地點決策、層級分析法、模糊擴展層級分析法、多目標規劃、線性規劃、經濟通貨膨漲。

Keywords: Location decision、AHP、FEAHP、MOP、LP、Economic inflation

1. Introduction

Location decisions are closely concerned an organization futuristic strategy management to face the actual economical changing. For example, a low-cost producer might processes in a location where the labor costs are lower. And a low-cost transportation might processes in a location where was near the market or raw material. The manufacturing location problem has been noticed in academicians and practitioners on the last several decades. The optimal location was determined concerning with the relevant factors. Such as the marketing opportunity, the living quality, the worker characteristic, the material cost and the transportable expense. However, the firms may face these problems to use the traditional evaluation method. In fact, the different criteria will found more complicated factors in today industry. Now the analytic hierarchy process (AHP) has widely used to tackle the multi-decision problems. In spite of it is popularity and simplicity in the conception, this AHP model was often criticized about its inability to adequately handle the relative uncertainty factors. The AHP traditional formula was only judged the related exact numerals. But the human's preference might be unable to assign a exact numeral in many practical cases. Because of the evaluation criteria are very subjective perception for each decision maker. Therefore, this paper desirable used the fuzzy evaluation method to solve the relative uncertainty problems.

The paper hope to improve the typical AHP model that met the uncertainty variable to facilitate the selection process; the fuzzy extended AHP (FEAHP) utilized the triangular fuzzy numeral to represent the final priority of decision criteria [6], and to efficiently handle the uncertainty variable decision problems [7]. The fuzzy set theory resembles human's reasoning perspectives in the uncertainty judgment. The FEAHP method has the mathematical base to represent uncertainty factors and to provide formalized the tools dealing with the human's preference problems. The proposed FEAHP evaluation model utilized the triangular fuzzy numerals to make a pair-wise comparison scale to obtain the priorities of different selection criteria. Therefore, we calculated the priority of the each alternative then select the each criterion weight. In particular, the method can adequately handle the uncertainty factors to use in being economical inflation to solve these various factor problems.

2. Literature review

Any decision maker always faced these dilemmas, the systematic decision tools are needed to consider the multitudinous factors affecting the location decision problems. Such include the multiple objective programming (MOP) and the analytic hierarchy process (AHP) [8,9,10], in terms of use easily, data requirement, computational difficulty and sensitivity analysis capability. In considering the location problem must deal with a quite large the attribute numeral to provide an analytic hierarchy process within the analytic framework, which was first introduced by Saaty [5]. The AHP model has a special ability to solve the practical location problem without computational difficulty, but the MOP model would encounters the severely limits in the difficult problems for selection location [11]. In fact, the AHP application in the selective location problem is common illustrated by the prior works of Wu and Wu [12], Hedge and Tadikamalla [12], Erkut and Moran [13] and Min [15,16]. Although both AHP and MOP methods have some advantages over other existing approaches, they still suffered some criticisms. AHP cannot effectively take into account certain uncertainty problems to evaluate the location weights for both the marketing opportunity and living quality. The MOP inherent computational complexity affects many attributes in the essential selection. In MOP problems formulation, many objective constraints can be avoided in converting the priorities into a matrix of the pair-wise comparison. The drawback of MOP cannot accommodate subjective criteria [17]. Apart from the above mentioned techniques, O'Brien and Ghodsypour [18] proposed an integration of AHP and linear programming (LP) to consider both the tangible and the intangible factors in choosing the best suppliers and optimum order quantities. Now the fuzzy extended approach used in the case study, the proposed will be more efficient dealing with the weight problem for analysis the uncertainty factors.

This paper involving carefully attributes are discussed the relevant decision criteria such as marketing opportunity, living quality, worker characteristic, material cost, and transportation expenses. The back three criteria are the certainty factors, the data obtained from the local magazine information. The front two criteria are the uncertainty factors such two the marketing opportunity and the living quality. The research could provide the compound and suitable approach to tackle the fuzziness numerals, we also can aim at the complex and the inexact data to solve efficiently the location selection problems in the actually business scenario in the economical inflation period.

3. Selection criteria for evaluation optimal location

The manufacturing industry of the main objective (O) aims at the best profit, when we start to establish a new location to chosen a best potential location. We can attempt to identify the best one from several locations. In many situations, any location can not have significantly better in all various criteria. Perhaps we can accept the numerous locations from personal preference. Therefore, these acceptable locations have to make carefully evaluations whether conforms to the main objective, correlative criteria and various attributes. The evaluation method is depending on the actual situations to select an optimal location. The actual situations are including the material supply, the location accessibility, the consumer population, the traffic distribution, the worker attitude and the local living quality. These criteria were established the basis relevant information and expert opinions including the following five criteria; the marketing opportunity (C1) is very important criterion; its attributes included the population density, the market potential and the competitively pressures. The living Quality (C2) could affect their residence and working conditions, such as traffic situation, crime rate, climatic change, living expense and environmental pollution. The worker characteristics (C3) were related the production cost and the work efficiency including worker education level, wage rate, productive forces, work attitude and skill level. The material cost (C4) was related affective attributes for the purchasing price, the ordering times and the inventory cost. The transportation cost (C5) was always chosen a central region to reduce the distributive time and the storing cost considering highway, railway, airlift, and shipping condition.

3.1 Marketing opportunity (C_1)

The profit-oriented must considered the number of customers in the business region. The higher profit comes from more customers that have to select the population density higher region. The market potential increase where bring in the commercial rival increase, and then the competitive pressure will natural rise. The assessing location has to approach the potential markets for the decision maker. Because the economical inflation will generate higher unemployed rate causing the population outflow, the population density decreasing affect the fewer marketing opportunity, when the market potential reducing bring in the competition pressures certainly reducing. Therefore, we have discovered this factor is an uncertainty variable in inflation period, the attributes are including population density (A1), market potential (A2) and Competition pressure (A3).

3.2. Living quality (C_2)

The manufacturing industry will expect to hire the hundreds of employees; they want to select their residence in the better environment. Therefore, the selection good region could hire the better worker and could keep the outstanding staffs in the human resource demand. Because the economical inflation would generate the personal income reducing against of the household expense increasing; the income can not pay the expense bring in the living quality decreasing, the society possibly bring in the crime rate increasing to effect the resident environment. Furthermore, the local climate change frequently caused the human unable to endure such snow and rain. Therefore, we know that the living quality factor also is an uncertainty variable. We take into account the correlation attributes including the traffic congestion (A4), crime rate (A5), local climate (A6), living expense (A7) and environmental pollution (A8).

3.3. Worker characteristics (C_3)

The operation process will consider the labor cost and work efficiency, we must required the worker’s responsibility, the production quality, and the production quantity. The worker attitudes would directly affect the production line management, the good attitude able to obtain the good coordination, but the attitude is not good that will cause many puzzles in the management. Therefore, the worker coordination situation could directly reflect in the production cost. The above mentions need to estimate adequately each worker's characteristic in order to obtain the best management in the future. Since company choosing a location have to consider the local worker characteristics, the relative information were collected in the local magazines including local wage rate (A9), labor productivity (A10), worker attitude (A11), and technical level (A12).

3.4. Material cost (C_4)

The purchasing material always relate to the quantity size and the price range, actually situation would generate in the quantity increasing as the price decreasing. The order cost relate to the order times, the order times increasing relate to each purchasing quantity decreasing bring in the higher material cost, or the order times decreasing relatively increase the purchasing quantity that might incur the risk in the material price rising. The inventory cost relate to the store quantity, the store quantity too much would causes the inventory cost increasing, or store quantity too low would also generate in the supply product shortage. Therefore, the company chooses a best location in the material supply region or neighbor avoid to the price rising risk to reduce the material cost. The attributes are including the purchasing cost (A13), order cost (A14), and inventory cost (A15).

3.5. Transportation expenses (C_5)

The transportation expense was indicated that the distribution product and material to assign destinations, the goal is selection the most convenient transportation schedule to save the total transportation expense and to satisfy the supply and demand for customer. Therefore, the firms want to choose a best location; it essential consider in core region in order to seek the lowest expense and the shortest time. Because the transportation situations were existent traffic facilities, which can collect from the map including the highway (A16), railway (A17), airway (A18), and ship way (A19).

4. AHP methodology and discussion

The AHP is a visual scoring method that was designed to solve a complex decision problem, and turn into more simple hierarchy model then analyze each factor weight, which in the pair-wise comparison evaluated the priority weight, now included three hierarchies such correlative decision criterion $\left(C_i\right)$, attributes $\left(A_i\right)$, and locations $\left(L_i\right)$. The conceptual foundation of the AHP is referred to Refs $\left[19,5,20\right]$. The AHP is used suitably in location decision by two main reasons. (1) AHP is an effective tool for dealing with the tangible number (e.g. cost) in different scales; (2) AHP also is a measurement way that could prioritize the hierarchy and consistent judgment. AHP allows the location planner not only visualize preferences among the location alternatives, but also can identify the inconsistent judgments during the decision process for ensuring the competitive advantage in the future. The selective hierarchy has shown in Fig. 1.

The AHP often handle the number of attributes in tangible variables, as a decision method to decompose a complex problem of the multi-criteria decision into a simple hierarchy model [5], AHP is a measurement theory to provide hierarchy and consistency framework, and these factors evaluation value came from a group of decision makers. AHP incorporates with various evaluation values into a range coring in final selection decision, without involved with any personal subjective judgment, and then utilize the pair-wise comparisons of the alternatives, Saaty [21]. AHP has been successfully applied to the diverse array of the evaluative problem, the calculation procedure offered as follows:

First, the pair-wise comparison established the matrix A, and Let $c_1, c_2, \ldots, c_n$ denote a set of elements, which a_{ij} represents a quantity judgment for a pair of elements (c_i, c_j). The elements are formed a scale among the values 1, 3, 5, 7, and 9, where 1 refers to "equally important", 3 denotes "slight more important", 5 equals "strongly more important", 7 represents "demonstrably more important" and 9 denotes "absolute more important". Since yields a $n \times n$ square matrix A:

$$A = [a_{ij}]_{n\times n} = \begin{matrix} C_1 \\ C_2 \\ \vdots \\ C_n \end{matrix} \begin{bmatrix} 1 & a_{12} & \ldots & a_{1n} \\ 1/a_{12} & 1 & \ldots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ 1/a_{1n} & 1/a_{2n} & \cdots & 1 \end{bmatrix} \qquad (1)$$

Where $a_{ij}=1$ and $a_{ij}=1/a_{ij}$, $i, j = 1,2,\ldots,n.$ in matrix A, the problem becomes one of assigning to the n elements $c_1, c_2, \ldots, c_n$ a set of numerical weights $w_1, w_2, \ldots, w_n$ that reflect the recorded judgments. If A is a consistency matrix, the relations between weights w_i and judgment a_{ij} are simply given by $w_i / w_j = a_{ij}$ and $c_1, c_2, \ldots, c_n$.

$$A = \begin{matrix} c_1 \\ c_2 \\ \vdots \\ c_n \end{matrix} \begin{bmatrix} w_1/w_1 & w_1/w_2 & \cdots & w_1/w_n \\ w_2/w_1 & w_2/w_2 & \cdots & w_2/w_n \\ \vdots & \vdots & \ddots & \vdots \\ w_n/w_1 & w_n/w_2 & \cdots & w_n/w_n \end{bmatrix} \qquad (2)$$

The normalization of the geometric mean (NGM) method is used to determine a importance degree of the decision maker requirements. Let W_i denoted the importance degree (weight) for the i_{th} criteria, then multiplied by elements in each line for judgment matrix M_i

$$M_i = \prod_{j=1}^{n} a_{ij}$$

And calculate its geometry mean value

$$\overline{W_i} = \sqrt[n]{M_i} \tag{3}$$

Each weight of the different criteria

$$W_{C_i} = \sqrt[n]{\prod_{j=1}^{n} a_{ij}} / \sum_{i=1}^{n} \prod_{i=1}^{n} a_{ij} \tag{4}$$

Saaty[19] suggested that the largest eigenvalue $\lambda_{\max}$ would be

$$\lambda_{\max} = \sum_{j=1}^{n} a_{ij} \frac{w_j}{w_i}. \tag{5}$$

If A is a consistency matrix, eigenvector X can be calculated by

$$(A - \lambda_{\max} I)X = 0.$$

Saaty[21] proposed utilizing consistency index (CI) and consistency ratio (CR) to verify the consistency of the comparison matrix. Both CI and RI are defined as follows:

$$CI = (\lambda_{\max} - n)/(n-1), \quad CR = CI / RI, \tag{6}$$

Where RI represents the average consistency index over numerous random entries of same order reciprocal matrices. If $CR \leq 0.1$, the estimate is accepted; otherwise, a new comparison matrix is solicited until $CR \leq 0.1$.

When we faced the relative intangible numbers, although the AHP has been widely used to address the multi-criterion decision problems, but it can not handle the uncertainty problems in decision different factors. Since the FEAHP method was utilized to calculate the interval weight that made the better weight expansion and the less weight reduction. It set up a discrete scale of one to nine; the relative different criteria involve the uncertainty variable in the personal perception [22]. Hence, the triangular fuzzy numbers are used to decide the priority of the decision variable. Synthetic extent analysis method is used to decide the final priority weights based on the triangular fuzzy numbers.

A fuzzy set [23,24] is characterized by a membership function, which assigns to each object a grade of membership ranging between 0 and 1. These n_1, n_2, n_3 denote the smallest possible value, the most promising value and the largest possible value to describe a fuzzy event. Where, $n_1 \le n_2 \le n_3$, it is a non-fuzzy number by convention. The membership function can be defined the changing gap for uncertainty variable as Fig.2.

(1) The horizontal axis represents a triangular fuzzy number N.

(2) The $\mu_N(x)$ value is the height ratio of the similar triangle in vertical axis.

$\mu_N(x) = \begin{cases} (x-n_1)/(n_2-n_1), & x \in [n_1, n_2] \\ (n_3-x)/(n_3-n_2), & x \in [n_2, n_3] \\ 0 & otherwise \end{cases}$	(7)

(3) The l_y, r_y denote the left- and right-hand side representation, the fuzzy number $\mu_N(x)$ value is respectively. The algebraic operations of the fuzzy numbers was used in this paper in [25]

$N = (N^{l(y)}, N^{r(y)}) = (n_1 + (n_2 - n_1)y, n_3 + (n_3 - n_2)y), \quad y \in [0,1]$	(8)

TFNs $N_i(i = 1,2,\ldots 9)$ are used to represent the pair-wise comparison of decision variables, $N_i = (n_{i1}, n_{i2}, n_{i3})$, where $i = 1,2,\ldots 9$ .and (n_{i1}, n_{i2}, n_{i3}) are the lower, middle and upper values of the fuzzy number N_i respectively.

The object set is denoted by $P = \{p_1, p_2, \cdots, p_n\}$ and the objective set is denoted by $Q = \{q_1, q_2, \cdots, q_m\}$, then according to the concept of extent analysis [6] each object is taken and extent analysis for each objective O_i is performed respectively. Therefore, the m extent analysis values are obtained for each object as the following signs:

$N_{oi}^1, N_{oi}^2, \ldots, N_{oi}^m$, where $i = 1,2,\ldots,n$, where all the $N_{oi}^j(j = 1,2,\ldots,m)$ are triangular fuzzy numbers.

The value of $\sum_{j=1}^{m} N_{oi}^{j}$ can be found by performing the fuzzy addition operation of m extent analysis values from a particular matrix such that

$$\sum_{j=1}^{m} N_{oi}^{j} = \left(\sum_{j=1}^{m} n_{1j}, \sum_{j=1}^{m} n_{2j}, \sum_{j=1}^{m} n_{3j} \right) \tag{9}$$

And the value of $\left[\sum_{i=1}^{n} \sum_{j=1}^{m} N_{oi}^{j} \right]^{1}$ can be obtained by performing the fuzzy addition operation of $N_{oi}^{j} (j = 1,2,\ldots,m)$ such that

$$\sum_{i=1}^{n} \sum_{j=1}^{m} N_{oi}^{j} = \left(\sum_{i=1}^{n} n_{1j}, \sum_{i=1}^{n} n_{2j}, \sum_{i=1}^{n} n_{3j} \right) \tag{10}$$

And $\left[\sum_{i=1}^{n} \sum_{j=1}^{m} N_{oi}^{j} \right]^{-1}$ can be calculated by the inverse as follow:

$$\left[\sum_{i=1}^{n} \sum_{j=1}^{m} N_{oi}^{j} \right]^{-1} = \left(\frac{1}{\sum_{i=1}^{n} n_{3j}}, \frac{1}{\sum_{i=1}^{n} n_{2j}}, \frac{1}{\sum_{i=1}^{n} n_{3j}} \right) \tag{11}$$

The value of fuzzy synthetic extent respect to the i_{th} object is defined as

$$F_i = \sum_{j=1}^{m} N_{oi}^{j} \otimes \left[\sum_{i=1}^{n} \sum_{j=1}^{m} N_{oi}^{j} \right]^{-1} \tag{12}$$

The degree of $N_1 = (n_{11}, n_{12}, n_{13}) \geq N_2 = (n_{21}, n_{22}, n_{23})$ is defined as

$$V(N_1 \geq N_2) = \sup_{x \geq y} \left[\min\left(\mu_{N_1}(x), \mu_{N_2}(y) \right) \right]^{1} \tag{13}$$

When a pair (x, y) exists such that $x \geq y$ and $\mu_{N_1}(x) = \mu_{N_2}(y) = 1$, then we have $V(N_1 \geq N_2) = 1$. Since N_1 and N_2 are convex fuzzy numbers,

$V(N_1 \geq N_2) = 1$ if $n_{11} \geq n_{21}$

And

$$V(N_2 \geq N_1) = hgt(N_1 \cap N_2) = \mu_{N_1}(d) \qquad (14)$$

Where d is the ordinate of the highest intersection point D between μ_{N_1} and μ_{N_2}. when $N_1 = (n_{11}, n_{12}, n_{13})$ and $N_2 = (n_{21}, n_{22}, n_{23})$ then ordinate of D is computed by

$$V(N_2 \geq N_1) = hgt(N_1 \cap N_2) = \frac{n_{11} - n_{23}}{(n_{22} - n_{23}) - (n_{12} - n_{11})} \qquad (15)$$

For the comparison of N_1 and N_2, both the values of $V(N_1 \geq N_2)$ and $V(N_2 \geq N_1)$ are required. The $\mu_{N_1}(d)$ is shown as Fig.3. for $V(N_2 \geq N_1)$ volue.

The degree possibility for a convex fuzzy number to be greater than k convex fuzzy numbers $N_i(i = 1,2,\ldots,k)$ can be defined by

$$\begin{aligned} &V(N \geq N_1, N_2, \ldots, N_k) \\ &= V[(N \geq N_1) and (N \geq N_2) and \ldots and (N \geq N_k)] \\ &= \min V(N \geq N_i), i = 1,2,\ldots,k. \end{aligned} \qquad (16)$$

$$\text{If } \; m(p_i) = \min V(F_i \geq F_k), \qquad (17)$$

for $k = 1,2,\ldots,n; k \neq i$. Then the weight vector is given by

$$W_p = (m(p_1), m(p_2), \ldots, m(p_n))^T \qquad (18)$$

where $p_i(i = 1,2,\ldots,n)$ are n elements.

After normalizing W_p, we get the normalized weight vectors

$$W_p = (w(p_1), w(p_2), \ldots, w(p_n))^T \qquad (19)$$

where W_p is a non-fuzzy number and this gives the priority weights of one alternative over other.

5. Application of the between tangible and intangible attributes use in selection locations

The AHP method has widely used in various selection problems because it has simplicity and practicality analysis technique, the factor eigen-value came from the expert opinions and actual information to compose the evaluation variables, the variables were analyzed by the relevant certainty variable. However, we have frequently faced the uncertainty problems. For instance, when the economical index increase as marketing opportunity naturally increase, or when the economical index decrease as the marketing opportunity decrease, the marketing opportunity eigen-value can not indicates an exact number. Therefore, the paper will use the FEAHP method to solve the uncertainty variable and utilize the AHP method to solve the certainty variable in the existent evaluation problems. This hybrid AHP method could be accepted because its analysis logic is worth confidence in without complicated computation process. The AHP-based evaluation model is developed in the selection location, the main function is more reasonably evaluation in order to understand the competitive advantage in the future, and the evaluative process will be detailed explanation as follows:

Step 1: Define the criteria and the attributes to assess the profit orientation for selection an optimal manufacturing industry location.

Step 2: Established a hierarchical framework as the selection model, and discussed the important indicators by the expertly opinions and the statistical information, the hierarchy factors include the objective, the criteria, the attributes and the alternatives show in Fig.1 and Fig.2.

Step 3: The decision maker made a pair-wise comparison of the decision elements, and the assignment relative scores combined the square matrix to form the application formula (1).

Step 4: Calculates the eigenvector of the pair-wise comparison to solve the tangible factors to utilize the AHP method as formula (2)-(4).

Step 5: Tests each comparison matrix consistency to use formula (5)-(6).

Step 6: Calculates the eigenvector of the pair-wise comparison to solve the intangible factors to utilize the FEAHP method as formula (7)-(19)

Step 7: Aggregate the relative eigenvector using the geometric mean method in order to calculate the relevant weights for each alternative showing table (1)-(11).

Step 8: Combine the relative weights of each criteria showing table (12).

Step 9: Sensitivity analysis of three locations depend on the five criteria weight, the final priority weight is shown as follows ($0.394 \geq 0.324 \geq 0.282$), and the ($L_1$) is elected the most optimal location.

This study constructed the factor indicators how selected an optimal manufacturing location to understand the competitive advantage. The hybrid AHP method adopted with relevant eigenvalue by the expertly opinions and the statistical information to avoid individual perspectives. The AHP and FEAHP evaluation model could mix to assess the correlation variables, and combined the relevant criteria to establish the hierarchy framework to evaluate the priority weight become a new technology.

The fuzzy number matrix of the five criteria constructed the pair-wise comparison model to shown in Table (1). The matrix function has to check whether consistency by the relevant vector, the computation each criterion weight will utilizes the geometric mean method.

In front of the computation process should identify the variably characteristic, when the certainty variable calculates the relative weights to utilize the AHP method. Another, the uncertainty variable calculates the relative weights that should use the FEAHP method for expansion the priority weight gap. Furthermore, we calculate each the attribute weight, and calculate the priority weight of the individual criterion. Finally, we combine all weights to constitute the fuzzy number matrix. We can found the priority weight of the assignable locations, which indicated that the rank order $\left(L_1 \geq L_3 \geq L_2\right)$ showed in Table (12), this is a usefully manner as avoided the personal subjective conception and preference for the reasonable decision making.

6. Conclusions

Many countries always could generate the economical inflation from the energy price risen, the countries must faced about the various political and economical problems, such as the population outflow, the individual income reduction, the family expense increasing, the market depression, the societal security worsening and the living quality lower. In particular, the paper utilizes the AHP method to solve the certainty problems. And another utilizes the FEAHP method to solve the uncertainty problems. Two methods utilize alternately to handle market changing within the economical inflation period. Its major functions are that move the weight gap; to expand the greater weight and to reduce the fewer weight, this method is reasonable expansion gap ratio for evaluation uncertainty factors.

The AHP model was designed to evaluate advantaged location from current candidate. This model has widely used that only aims at the certainty variable and the statistical data. Such as the marketing opportunities, the living quality, the worker characteristic, the material cost and the transportation expense. In consequence, it can aid the planner to analyze the various criteria; the firm can carefully consider the operating strategic during the economical inflation.

The hybrid AHP method is simplicity and availability in evaluation processes, it has not complicated calculation, and has not the complex computer program. In the recently, we faced the energy price arisen in the around world, many countries incurred the severe economic inflation, such as the national production index dropping, the people living quality changing, the region crime rate rising, and the unemployment rate going up, the above mentioned the relevant variables can proved that is unable to use the AHP model to solve the uncertainty problems. In fact, these variables are not the exact data because the variable continues changes during the economic inflation. But we noticed that the changing variable will still maintained at the stable gap. Since, the paper proposed that use the FEAHP method to handle the evaluation problems; to causes the greater weight expansion and to causes the lower weight reduction, this evaluation model is flexibility and reliability in evaluation uncertainty variable.

Before, I have been collected many relevant literatures, which included MOP, LP, LINGO AND AHP. These models must obtain the priority weight from the several selection cases. Although, these literatures were only discussed the exact and the inexact factors. Where had not discovered the synthetic variable to select optimal location in the current economic inflation. Therefore, this paper utilizes the hybrid AHP model to consider both the certainty and the uncertainty variables, which can solve the current problems and expanding to other areas.

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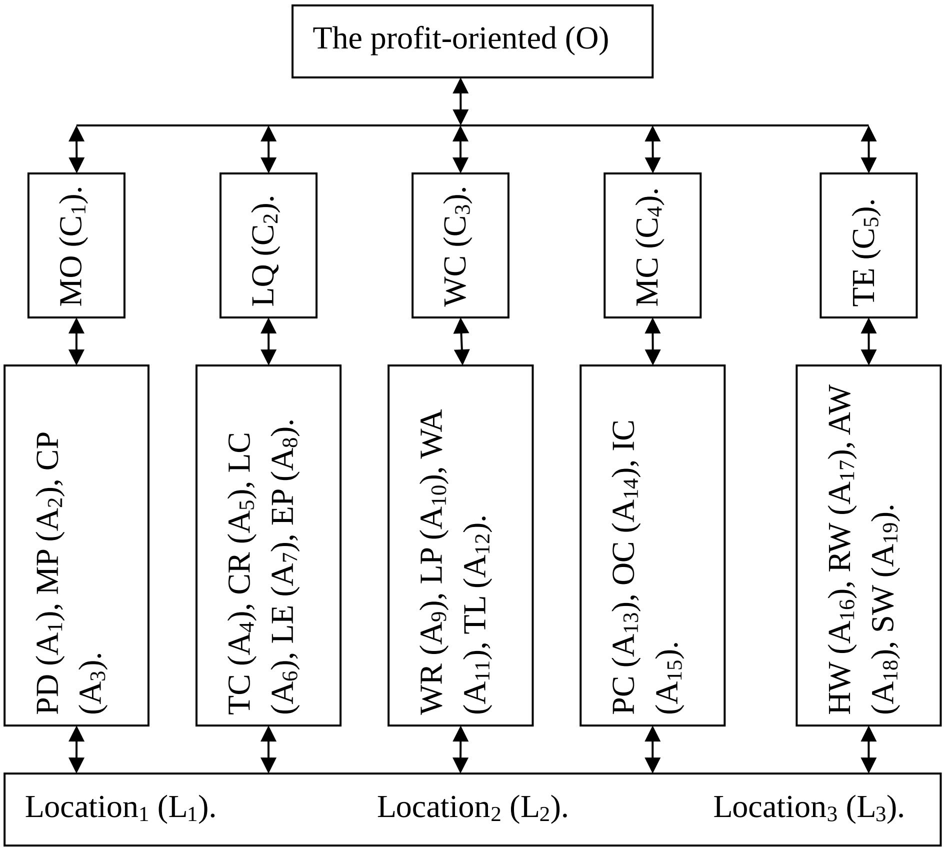
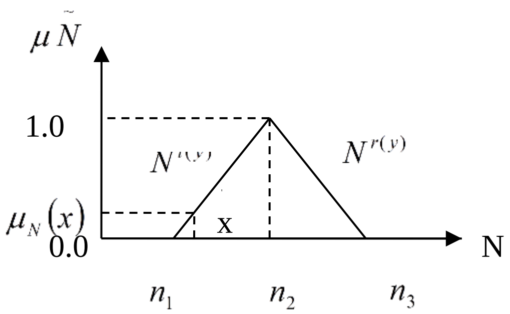


Fig. 1. Hierarchy for the location selection.



Feg.2. The relational chart of the triangular fuzzy numbers

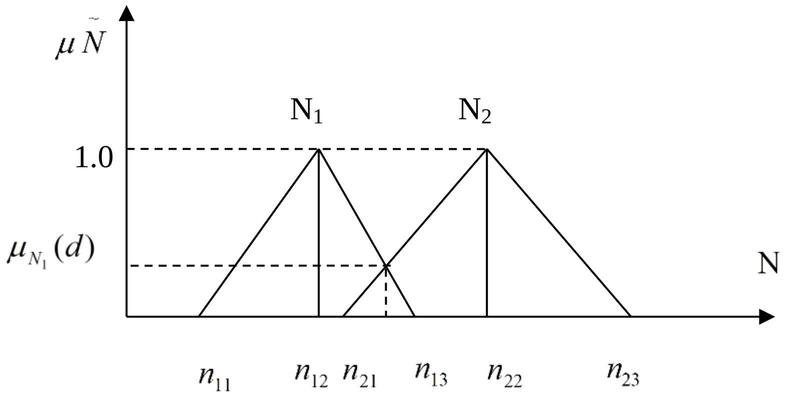


Fig.3. The $V(N_2 \geq N_1)$ height value calculated from N_1, N_2 in intersection point.

O	C_1	C_2	C_3	C_4	C_5	$\overline{W_i}$	W_O
C_1	1	2	3	5	7	2.914	0.408
C_2	1/2	1	3	4	6	2.408	0.337
C_3	1/3	1/3	1	2	3	0.922	0.129
C_4	1/5	1/4	1/2	1	3	0.596	0.083
C_5	1/7	1/6	1/3	1/3	1	0.305	0.043
$\lambda_{\max} = 5.139; CI = 0.035; CR = 0.031 \leq 0.1$							

Table 1.The evaluation of the five criteria with respect to the overall objective

C_1	A_1	A_2	A_3	W_P	W_{C_1}
A_1	1,1,1	3/2,2,5/2	7/2,4,9/2	1.000	0.784
A_2	2/5,1/2,2/3	1,1,1	3/2,2,5/2	0.113	0.088
A_3	2/9,1/4,2/7	2/5,1/2,2/3	1,1,1	0.163	0.128

Table 2. The fuzzy evaluation of the attributes with respect to criterion C_1

C_2	A_4	A_5	A_6	A_7	A_8	W_P	W_{C_2}

A_4	1,1,1	3/2,2,5/2	3/2,2,5/2	3/2,2,5/2	5/2,3,7/2	1.000	0.378
A_5	2/5,1/2,2/3	1,1,1	1/2,1,3/2	1/2,1,3/2	3/2,2,5/2	0.414	0.157
A_6	2/5,1/2,2/3	2/3,1,2	1,1,1	1/2,1,3/2	3/2,2,5/2	0.429	0.162
A_7	2/5,1/2,2/3	2/3,1,2	2/3,1,2	1,1,1	3/2,2,5/2	0.498	0.188
A_8	2/7,1/3,2/5	2/5,1/2,2/3	2/5,1/2,2/3	2/5,1/2,2/3	1,1,1	0.303	0.115

Table 3. The fuzzy evaluation of the attributes with respect to criterion C_2

C_3	A_9	A_{10}	A_{11}	A_{12}	$\overline{W_i}$	W_{C_3}
A_9	1	2	2	3	1.861	0.413
A_{10}	1/2	1	2	3	1.316	0.292
A_{11}	1/2	1/2	1	2	0.841	0.187
A_{12}	1/3	1/3	1/2	1	0.485	0.108
$\lambda_{\max} = 4.073; CI = 0.024; CR = 0.027 \le 0.1$						

Table 4. The fuzzy evaluation of the attributes with respect to criterion C_3

C_4	A_{13}	A_{14}	A_{15}	$\overline{W_i}$	W_{C_4}
A_{13}	1	3	3	2.080	0.594
A_{14}	1/3	1	2	0.874	0.249
A_{15}	1/3	1/2	1	0.550	0.157
$\lambda_{\max} = 3.055; CI = 0.028; CR = 0.048 \le 0.1$					

Table 5. The fuzzy evaluation of the attributes with respect to criterion C_4

C_5	A_{16}	A_{17}	A_{18}	A_{19}	$\overline{W_i}$	W_{C_5}

A_{16}	1	2	3	4	2.213	0.467
A_{17}	1/2	1	2	3	1.316	0.278
A_{18}	1/3	1/2	1	2	0.760	0.160
A_{19}	1/4	1/3	1/2	1	0.452	0.095
$\lambda_{\max} = 4.031; CI = 0.010; CR = 0.011 \leq 0.1$						

Table 6. The fuzzy evaluation of the attributes with respect to criterion C_5

W_{LC_1}	$A_1 = 0.784$	$A_2 = 0.088$	$A_3 = 0.128$	$Alternative\ pririot-yweight$
L_1	0.52	0.51	0.65	0.536
L_2	0.21	0.26	0.20	0.213
L_3	0.27	0.23	0.15	0.251

Table 7. Summary combination of priority weights: attributes of criterion C_1

W_{LC2}	$A_4 = 0.378$	$A_5 = 0.157$	$A_6 = 0.162$	$A_7 = 0.188$	$A_8 = 0.115$	$Alternative\ priority-weight$
L_1	0.23	0.23	0.12	0.46	0.24	0.256
L_2	0.26	0.18	0.57	0.22	0.49	0.317
L_3	0.51	0.59	0.31	0.32	0.27	0.427

Table 8. Summary combination of priority weights: attributes of criterion C_2

W_{LC_3}	$A_9 = 0.413$	$A_{10} = 0.292$	$A_{11} = 0.187$	$A_{12} = 0.108$	$Alternative\ priority-weight$
L_1	0.28	0.49	0.35	0.65	0.394
L_2	0.39	0.22	0.32	0.16	0.303

L_3	0.33	0.29	0.33	0.19	0.303

Table 9. Summary combination of priority weights: attributes of criterion C_3

W_{LC_4}	$A_{13} = 0.594$	$A_{14} = 0.249$	$A_{15} = 0.157$	$Alternative\ priority-weight$
L_1	0.20	0.19	0.18	0.194
L_2	0.48	0.49	0.55	0.494
L_3	0.32	0.32	0.27	0.312

Table 10. Summary combination of priority weights: attributes of criterion C_4

W_{LC_5}	$A_{16} = 0.467$	$A_{17} = 0.278$	$A_{18} = 0.160$	$A_{19} = 0.095$	$Alternative\ priority-weight$
L_1	0.69	0.35	0.55	0.17	0.524
L_2	0.11	0.35	0.18	0.00	0.177
L_3	0.20	0.30	0.27	0.83	0.299

Table 11. Summary combination of priority weights: attributes of criterion C_5

W_L	$C_1 = 0.408$	$C_2 = 0.337$	$C_3 = 0.129$	$C_4 = 0.083$	$C_5 = 0.043$	$Alternative\ priority-weight$
L_1	0.536	0.256	0.394	0.194	0.524	0.394
L_2	0.213	0.317	0.303	0.494	0.177	0.282
L_3	0.251	0.427	0.303	0.312	0.299	0.324

Table 12. Summary combination of priority weights: main criteria of the overall objective