Preliminary Study on Urban Tourism Carrying Capacity (UTCC): Theory Establishment, Modeling and Empirical
-- to Tokyo as an example

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With the development of economic and transportation, more and more people are choosing an urban as travel destination for leisure, shopping, entertainment, historical learning and so on, especially in the international tourism. Data from "Yearbook of China Tourism Statistics" shows the visitor number in 21 cities accounted more than 55% of the total visitor number in china in the past half year. Data from JNTO also shows the same result in Japan, the visit rate of foreigners to Tokyo reached 59.33% ranked No.1 in Japan cities in 2011.

Although tourism industry has accelerated the development of the urban a lot, many different level already appeared due to the short time the influx of passengers caused tensions, environmental damage, accommodation security deterioration phenomenon, it seriously will make tourism overall image sharp decline and even lead to travelers and travel between groups' untrust events.

Study on tourism carrying capacity can be traced back to the end of the nineties and has been attracted many scholars' attention, but for its research object attribute set is large and uncertainty, the research mostly is studied by a single attribute angle of view, replacing the behavior of the whole.

In view of this, the article tries in the tourism carrying capacity theory and the current urban tourism carrying capacity theory based on the relevant research results, on urban tourism carrying capacity from the overall and systematic perspective of theory building and using fuzzy multi-objective optimization method for touch, and discusses 8 kinds of morphology under the model fitting curve between the feature parameters, and to Tokyo as an example of the model through an empirical research, aimed at study on tourism carrying capacity for the urban to provide ideas and reference.

Key words: Urban Tourism Carrying Capacity (UTCC); Fuzzy Analytic Hierarchy Process; Multi-objective Optimization Model

1. Background

As in recent years the urban tourism industry has changed a process to accelerate the development of the city, many different already level appeared due to the short time the influx of passengers caused tensions, environmental damage, accommodation security deterioration phenomenon, serious will make tourism overall image sharp decline and even lead to travelers and travel between groups untrust event. The representative of golden week policy such as repeatedly discuss, Hainan market events, "urban heat island" effect brought about the snowline drawing back in Jade Dragon Snow Mountain in China.

The real problem constitutes the research background. Urban tourism industry on other industries is closely related. The rapid development of the tourism industry at the same time, to take into account with other city industry capacity of harmonious development, regardless of the industry, once beyond the tourism carrying capacity will lead to a variety of city problems, even the inter professional malignant chain reaction. Therefore, study on urban tourism carrying capacity has its realistic necessity.

The present academic background of thestudy is derived from the tourism carrying capacity (TCC) theory. However, to the carrier of the theory – the city, further in-depth study is necessity for its large range, multiple attribute collection objects. Carrying capacity as a measure of a situation and object relations concepts since the introduction of tourism, as TCC's further theoretical studies and the reality of the people to expand the scope of tourism activities, the scope of the object of study and its attribute set is also increasing. The single attribute of tourism destination and object of study has been unable to meet the needs of the development of reality. With a wide range of conditions, multiple attribute set as destination tourism carrying capacity research also emerge as the times require, and UTCC is one of the research.

But in view of the related research, only some tourism to state a number of case studies from ecology, and the single perspective in the United States. Japan, China and other Asian countries' tourism academia also does not see more. To the Asian urban as one of the objects of the study on tourism carrying capacity is still need for further development.

This paper is a part of "UTCC study" which aims to establish a model to evaluate urban tourism carrying capacity from 3 aspects: Urban facilities-environmental TCC, Urban social-cultural TCC, and Urban political-economic TCC. This presentation is the main content of the facilitical, ecological and economical factors in mathematical modeling on one part of elements in Tokyo as an example. Set up urban facilities as resource constraints and ecological and economical factors as objections of the model, set the relevant indexes for each factor, finally obtains the number of visitors that Tokyo bearing to the result. Model using FAHP (Fuzzy-AHP) on determining the index weight was studied, and using MOM (Multi-objective Optimization Method) to each index (constraints) target optimization, finally obtains the investigation results.

2. Establishment of Urban Tourism Carrying Capacity (UTCC) Theory

(1) Origination and definition of UTCC concept

UTCC concept is derived from the tourism carrying capacity (TCC)theory, and the foundation of TCC is based on carrying capacity (CC) theory. However, due to the different angle of multi-disciplinary research perspectives, the time of origin is not the same. From the application of ecology angle, Bartels[1] traced it back to1906, the U.S. Agricultural Yearbook; from population biology perspective, "Webster's Dictionary" [2] retrace its back to 1889; Malthus [3] in his book," the principle of population", laid the foundation for carrying capacity theory from demographic perspective in 1798, thereafter, Verhulst[4], and Pearl[5] were independently proposed the Logistic equation for the theory and provided the mathematical expression formula; Wagar [6] believes that people for land carrying capacity limited awareness of the problems began from the prehistory, "Old Testament" and many other books mentioned in passing, this is usually caused by food shortages, Haddon[7] also evidenced that human migration "is mostly by food shortages or population died as a result of"; even there is the scholar dates it back to ancient Greece[8]. Modern theory to urban carrying capacity is more inclined to study ecology theory origination.

On the origin of time accurate traceability problem from another angle that the carrying capacity is a multidisciplinary development to blend and the formation of the concept, it also indicates its application range.

The concept meaning, modern studies of carrying capacity of about in favor of the two representations: one is a certain period of time, not in the current circumstances do not permit reversal caused by the destruction of the case, a group of existing maximum number; the other one is a period of time, not in the current circumstances do not permit reversal of damage caused by case, situation of resources can be exploited degree maximum. The two representations show the two research perspectives, a starting point is to study situation object population, and another is to study the situation itself resource can be used. But whether the former or the latter, capacity to study is the circumstances and the object can be maintained between the harmonious coexistence state relationships.

(2) Establishment of UTCC theory

From the CC theory to TCC and to UTCC, from the discipline of vertical development, it shows the CC research from animal husbandry of bearing capacity in the initial simple ecology to complex human social carrying capacity research is gradually in-depth and refinement, which in addition to science development and also benefits from the related mathematics theory of development.

From the crosswise development, UTCC research has involved the tourism science, ecology, sociology, political science and other subjects, the research object gradually contains more complex attributes to elements and an open platform for carrying multiple attribute collection of elements of UTCC study on the theory is one of the development directions and is also the purpose of this article.

UTCC is an extension of the concept of TCC as the carrier of the tourism area in urban. The theory is based on CC research, inspection is not under the premise of unacceptable negative influence which is caused by the urban and tourism related factors (environment, society, economy etc) and is a maximum utilization of the urban tourism related factors. From the tourism resources tangible supply side, UTCC including urban and tourism ecological environment related resources, artificial facilities resources, physics economical resources, social cultural resources, all kinds of enterprises and product resources and so on.

These resources affecting UTCC from both physical and non-physical level, but also restricts the urban can be utilized elements of tourism. As a resource for some reason by damage to the carrying capacity reduce will directly triggered rejection effect, this effect is often swift and violent, but the duration is temporary, such as accommodation and transportation tension during holidays, occurrence of cyanobacterial (blue-green algae) blooms mainly due to environmental problems and so on.

With the existing urban tourism resources maximum capacity number of tourists as city acceptable maximum carrying capacity measure accordingly, from 3 aspects of city tourism carrying capacity study

1) Urban Facilities-Environmental (F&E) TCC

Urban F&E TCC refers to the maximum utilization of urban F&E elements, under the premise without causing unacceptable negative influence to urban F&E elements.

This includes two meanings, one is associated with the infrastructure of urban tourism (such as hotels, restaurants, tourist service center, etc.) or its products (such as water supply, power supply, gas and other resource) elements of the carrying capacity; on the other hand is natural ecological of the urban (such as the green space, water pollution, air pollution, etc.) elements of the carrying capacity.

2) Urban Social-Cultural (S&C) TCC

Urban S&C TCC refers to the maximum utilization of urban S&C elements, under the premise without causing unacceptable negative influence to urban S&C elements.

S&C factors are the spiritual and high correlation, specific to its classification and definition needs to be further studied. Urban S&C factors mainly include the urban's unique folk custom, fallowed on foreign and local tourists' inclusion-exclusion situation, urban people's social psychology and so on.

3) Urban Political-Economic (P&Ec) TCC

Urban P&E TCC refers to the maximum utilization of urban P&E elements, under the premise without causing unacceptable negative influence to urban P&E elements.

Political factor mainly refers to the policies and political or policy triggered by events on the urban tourism influence, and economic element refers to the city economic scale on UTCC, including the scale of urban tourism investment, per-capita spending of urban visitors and so on.

3. Modeling of UTCC

(1) Index System

UTCC study is a huge project, according to the level of relationship between delivery, indexes inspection system can be established in table 3-1.

Table 3-1. Index System of UTCC

Level (I)	Level (II)	Level (III)	Level (IV)
UTCC	U F&E TCC (II_1)	U F TCC (III_1)	U F_1 TCC
			…
			U F_m TCC
		U E TCC (III_1)	U E_m+1 TCC
			…
			U E_n TCC
	U S&C TCC (II_2)	U S TCC (III_2)	U S_n+1 TCC
			…
			U S_k TCC
		U C TCC (III_3)	U C_{k+1} TCC
			…
			U C_p TCC
	U P&Ec TCC (II_3)	U P TCC (III_4)	U P_{p+1} TCC
			…
			U P_q TCC
		U Ec TCC (III_5)	U Ec_{q+1} TCC
			…
			U Ec_t TCC

(2) Reviewing Method

UTCC is an open platform, not only to

study the existing resources under the condition of carrying capacity, but also for the future new elements to provide reservation study space, and can provide tangible and intangible resources investigation at the same time provide a good platform interface. Under ideal conditions of UTCC, the study platform should have the resource adjustment according to the historical data and the prediction of future situations.

The above considerations, selection of triangular fuzzy analytic hierarchy process (FAHP)[9] and multi objective optimization method (MOM)[10] by means of integration of UTCC were studied.

FAHP method in analytic hierarchy process (AHP) developed on the basis of, mainly for AHP process fuzzy understanding and language evaluation logic adaptive problems from the angle of fuzzy theory to solve, suitable for UTCC study in qualitative research, especially psychiatric and psychosocial aspects of intangible resources evaluation.

Multi-objective optimization method (MOM) is a 1961 American mathematician Charles and Cooper first proposed, it can be for city tourism carrying capacity study provides an open and continuous research platform, many resources are regarded as the model of a constraint or target, and the target is its own independent investigation in the platform is open, you can use different methods, but also according to the needs of study into pieces between the target and the conversion, and then to research for different constraint conditions of the research target.

The two research methods combined for UTCC study provide preliminary research methods.

Specific process is as follows:

Definition of real number set R fuzzy number M, if its membership function satisfies the condition:

$$M(x)=\begin{cases}(x-l)/(m-l) & l\le x\le m\\ (x-u)/(m-u) & m\le x\le u \quad (l,m,u\in R, l\le m\le u)\\ 0 & \text{others}\end{cases}$$

Then $M(l,m,u)$ as a triangular fuzzy number. Triangular fuzzy number operation rules are as follows:

$M_1=(l_1,m_1,u_1)$, $M_2=(l_2,m_2,u_2)$ for the two sets, triangular fuzzy number, then,

$$M_1\oplus M_2=(l_1+l_2,m_1+m_2,u_1+u_2) \quad \cdots \quad (1)$$

$$M_1\otimes M_2\approx(l_1l_2,m_1m_2,u_1u_2) \quad \cdots \quad (2)$$

$$M_1-M_2=(l_1-l_2,m_1-m_2,u_1-u_2) \quad \cdots \quad (3)$$

$$\lambda M=(\lambda m,\lambda l,\lambda u) \quad \cdots \quad (4)$$

$$(l,m,u)^{-1}=(\frac{1}{u},\frac{1}{m},\frac{1}{l}) \quad \cdots \quad (5)$$

Which $\oplus$, $\otimes$ are fuzzy numbers addition and multiplication operator.

With FAHP through expert questionnaire on index weight evaluation, and used in the form of triangular fuzzy numbers expressed in written form, judgment matrix, $R=(r_{ij})_{n\times n}$, in which, $r_{ij}=(l_{ij},m_{ij},u_{ij})$, m_{ij} said i index than the j target important degree, using the1-9 scaling law (Table 3-2.), u_{ij} and l_{ij}, are respectively the upper and lower bounds.

Table 3-2. Judgment Matrix Scale and Meaning

Scaling	Meaning
1	The two elements, an element and other elements are equally important.
3	Two elements, one element to another element slightly more important than.
5	The two element, an element than another element was important.
7	The two elements, an element than another element strongly important.
9	The two elements, an element than

	another element of extreme importance.
2,4,6,8	The two adjacent judgment of value.

In the FAHP method studies show that, at the time, $1/2<\alpha,\beta<1(\alpha=m_{ij}-l_{ij},\beta=u_{ij}-m_{ij})$, the fuzzy probability and confidence are more suitable, the results are compared with the idea[11], and in $R=(r_{ij})_{n\times n}$, $r_{ji}=(r_{ij})^{-1}$.

Comprehensive evaluation index weights calculation formula for:

$$M_i=\sum_{j=1}^{n}M_i^j[\sum_{i=1}^{n}\sum_{j=1}^{n}M_i^j]^{-1}\quad (i,j=1,2,\cdots n)\quad (6)$$

One M_i^j of the i evaluation indexes relative to the j evaluation target important degree, i.e. $M_i^j=r_{ij}$

The index weight normalization processing can be performed in the following manner: $M_1=(l_1,m_1,u_1)$, $M_2=(l_2,m_2,u_2)$, make $P(M_1\geq M_2)$ said triangular fuzzy number the possibility that $M_1\geq M_2$,

at the time $m_1<m_2$,

$$P(M_1\geq M_2)=\begin{cases}\dfrac{l_2-u_2}{m_1-u_1-(m_2-l_2)} & l_2<u_2\\ 0 \quad l_2\geq u_2\end{cases}\quad (7)$$

at the time $m_1>m_2$,

$$P(M_1\geq M_2)=1\quad (8)$$

Make an evaluation index is superior to other evaluation index of pure test measure, then,

$$\begin{aligned}&d'(B_i)\\&=P(M_i\geq M_1,M_2,\cdots,M_{i-1},M_{i+1},\cdots,M_n)\\&=\min P(M_i\geq M_k)\\&(k=1,2,\cdots,n,k\neq i)\end{aligned}\quad (9)$$

The entire evaluation index weight vector:

$$W'=(d'(B_1),d'(B_2),\cdots,d'(B_n))^T\quad (10)$$

After normalization processing, can be normalized weighted value of evaluation index:

$$W=(d(B_1),d(B_2),\cdots,d(B_n))^T\quad (11)$$

In which:

$$d(B_i)=\frac{d'(B_i)}{d'(B_1)+d'(B_2)+\cdots+d'(B_n)}\quad (12)$$
$$(i=1,2,\cdots,n)$$

After index weight matrix, multiple objectives optimization method can be studied for the index value modeling, model as follows:

$$\min f=\sum_{k=1}^{\lambda}P_k\times\left[\sum_{i=1}^{m}w_{ki}d_i^-+\sum_{i=1}^{m}w_{ki}d_i^+\right]$$

$$\begin{cases}\sum_{j=1}^{n}C_{ij}\times X_j+d_i^--d_i^+=g_i\quad (i=1,2,\cdots,h)\\ \sum_{j=1}^{n}a_{ij}\times X_j\leq b_t\quad b=h+1,h+2,\cdots,m\\ X_j\geq 0\quad (j=1,2,\cdots,h)\\ d_i^+\geq 0,\quad d_i^-\geq 0,\quad i=1,2,\cdots,m\end{cases}\quad (13)$$

Type: X_j as the decision variable; d_i^+, d_i^- for the positive and negative deviations; C_{ij} for the constraints of coefficient of i project; a_{ij} for the t resource constraints in the X_j coefficient, general for each resource unit consumption quota; g_i, for the i, is the goals of the established value; b_t, the t resource constraints limit value for the target; P_k priority, target priority level is not variable, also is not a constant, it only to show that different target sequence, the priority is usually determined by the decision maker of enterprise department according to specific circumstances and the goals of the order of priority to be determined; $w_{ki}d_i^-$, $w_{ki}d_i^+$ for class k priority goal of weighted d_i^-, d_i^+ coefficient.

(3) Model Function and Evaluation

The multi objective optimization method

to establish the UTCC model on one hand according to the constraint elements of historical data to examine past tourism carrying capacity of the urban, on the other hand, can be based on this model to predict the future situation of the UTCC. It also integrates the city mutual comparison function.

The prediction function of the model is divided into two ways, one is based on the respective constraints factor itself historical data to make predictions curve and draw predictive value, the final summary in the model that the total predictive value. The other is based on the model calculated total target of historical data, by which could made forecast curve obtained by the predicted future value.

The former is from the part looks, more suitable for in quantitative form test index prediction, while the latter is from the whole, more suitable for the development and change point of view to examine the urban tourism carrying capacity of the future. And the latter also apply to the non quantitative test index prediction.

For evaluation of the model, it is mainly based on the model value and the actual value of the historical data curve fitting of multiple related parameters from different angles on the UTCC evaluation. Related parameters and function mainly has the curve fitting correlation coefficient (r) [12], curve line spacing function (d), curve surround area function (S).

Curve fitting correlation coefficient r describes the model data fitting curve and the actual data fitting curve linear relationship, is used to describe the city tourism carrying capacity and the actual number of tourists along with the time development trend. It belongs to the model curve fitting overall trend judgment, $r \in [-1,1]$. When $r \in (0,1)$ the said model curve and actual curve has a certain degree of linear positive correlation; When $r \in (0,1)$ the said model curve and actual curve has a certain degree of negative linear correlation. As $|r|=1$, for completely linear relationship, and $|r|$ the closer to 1 the linear relationship more closely; when $|r|=0$ there is no linear relationship, the closer to 0 the linear relation is more weakly.

Curve line spacing function (d) describes the difference between model value and the actual value. It represents the approximation degree of the model value and the actual value, and is used to describe the constraint urban tourism resource utilization, but also used to describe the city of tourism resources development space, for the instantaneous value, $d \in (-\infty,+\infty)$.

When $d \in (0,+\infty)$, the model value is greater than actual value model, said there is still development space for urban tourism developing. But if the d in the positive range has high value, it also indicates that the urban does not have very good use of the factor to promote its tourism development; when $d \in (-\infty,0)$, the time to illustrate the practical value exceeds the model value, in the model of resources limited under the conditions of urban tourists have been overloaded. d in negative within the small values illustrate the overload situation worse; when d=0 (the theoretical value) or in the vicinity of in a small range (actual value) representation, model value and the actual value generally is corresponding, the urban of current resource utilization factor more fully, but also in the existing constraint conditions in the city's tourism development has very little space.

d on the specific value and corresponding to the morphology of the city according to a large number of historical data will be accumulated in order to make a judgment, and different city has different range. In addition, for the d group from the selection can be flexible to change, to illustrate in different time periods under conditions of different UTCC model and real value of the state.

Curve of area function (S) is encircled model values of fitting curve and the actual value of curve fitting in a specific time interval surround area numerical value, used to describe a given period of time difference value of urban tourism bearing the total number and the actual total number. The S value is indicative of a given time period can be greater than the actual bearing the total number of tourist visitors total number, S negative value for a given period of time that can bear the total number of tourists is less than the actual occurrence of the total number of tourists. The S computing time to consider two curves intersect, respectively, before and after the intersection point of urban tourism carrying capacity are described.

The assumed model value and the actual value of the fitting curves are straight line, horizontal axis for time, vertical axis for receiving the number, model of value and the actual value of fitting curve correlation and the parameters such as shown in fig.3-1 to fig.3-8.

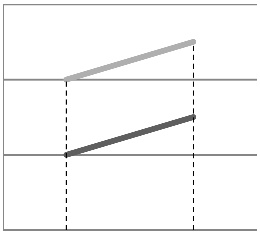


Fig.3-1. r=1, d>0,$S(x)|_a^b > 0$

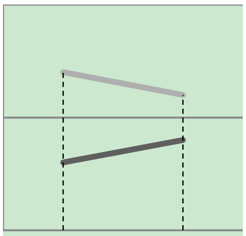


Fig.3-2. -1<r<0, d>0,$S(x)|_a^b > 0$

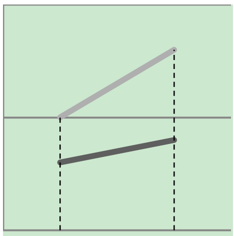


Fig.3-3. 0<r<1, d>0, $S(x)|_a^b > 0$

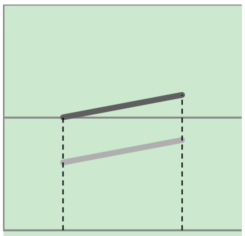
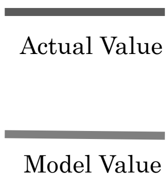


Fig.3-4. r=1, d<0, $S(x)|_a^b < 0$



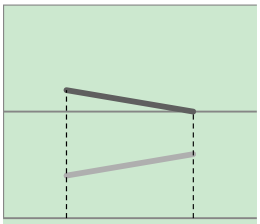


Fig.3-5 -1<r<0, d<0,$S(x)|_a^b > 0$

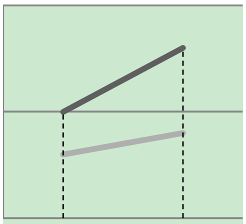


Fig.3-6 0<r<1, d<0, $S(x)|_a^b < 0$

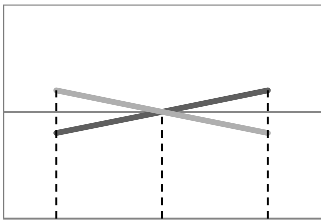


Fig.3-7 -1<r<0; d<0,$S(x)|_a^b < 0$, x∈(a,b); d>0,$S(x)|_a^b > 0$, x∈(b,c)

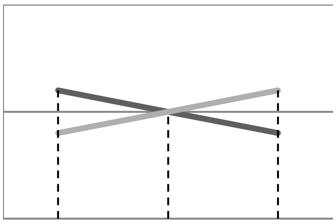


Fig.3-8 -1<r<0; d>0,$S(x)|_a^b > 0$, x∈(a,b), d<0, $S(x)|_a^b < 0$, d∈(b,c)

4. Application Study of the Model (to Tokyo as an example)

This article only choose tourism urban infrastructure elements, environmental factors and economic factors, data selected in year of 2009, Tokyo (Table.4-1). The infrastructure element of Tokyo is as the constraint condition of the model, and the environmental and economic factors are as the object of the model.

Table.4-1. Tokyo UTCC evaluation elements and corresponding index system

Level (I)	Level (II)	Level (III)	Corresponding Index	Maximum Capacity	Actual Amount	Per Capita Actual Volume*
Evaluation elements of UTCC in Tokyo (I)	Elements of Facilities Capacity (U F TCC) (II_1)	Accommodation reception capability index (III_1)	Hotel beds number (beds / day)	146206	94595	——
		Electric power supply facilities production capacity index (III_2)	Electric power supply facilities of TEPCO** (kw^2)	64487000	59990000	1.2389
		Metropolitan water supply facility production ability index (III_3)	Metropolitan water supply (m^3 / day)	6859500	4408003	0.3144
		Metropolitan sewer facilities processing capability index (III_4)	metropolitan sewage treatment (m^3 /day)	7658450	5768271	0.4114
		Garbage treatment facilities capacity index (III_5)	Sludge incineration (t/ day)	6660	1252	8.9296×10^{-5}
	Elements of environment Capacity (U E TCC) (II_2)	Tokyo SO_2 carrying capacity index (III_6)	SO_2 (PPM)	0.04	0.002	1.4265×10^{-10}
		Tokyo NO_2 carrying capacity index (III_7)	NO_2 (PPM)	0.04	0.021	1.4978×10^{-9}
		Tokyo O_x carrying capacity indicators (III_8)	Ox (PPM)	0.06	0.030	2.1397×10^{-9}
		Tokyo SPM carrying capacity indicators (III_9)	SPM (PPM)	0.1	0.023	1.6404×10^{-9}
	Elements of economic Capacity (U Ec TCC) (II_3)	Tokyo Tourism Economic Assessment East price index (III_{10})	Tokyo Travel Consumption (yen / day)	——	1.0959×10^{10}	9506.6081

Source: according to the Tokyo Metropolitan Government in 2009 statistical data processing (http://www.toukei.metro.tokyo.jp/index.htm)

Notes.

*. In Tokyo in 2009 the total population is 12868000 people, tourists is a total of 420760000 people. The per capital amount = actual date / Tokyo metropolitan daily total population, here in Tokyo resident population and average daily number of tourists and instead of Tokyo Metropolitan Daily population gross value. So the

daily total population of Tokyo is about 14020767 people in 2009.

**. In order to ensure the safe operation of electric power, electric power the actual amount of Tokyo Electric Power Company in2009 area of the peak electricity consumption, the Tokyo area maximum power consumption occurred in July 23, 2009, the value for the 17370000kw.

(1) Index weight of evaluation results

In table.4-1., II_1 as constraint condition, II_2 and II_3 as a model target, therefore it is only need to do with the after two corresponding indexes relative to the total goal — UTCC of Tokyo (I) for the weight analysis by FAHP.

This study selected 5 experts (L_1~L_5) questionnaire investigation, in which layer II_2 and II_3 is completely hierarchy, son of the criterion layer —layer III_6~III_{10} is not fully hierarchical structure to the total goal I, related algorithms are as follows.

Table 4-2. Index Fuzzy Judgment Matrix of Layer II_2 & II_3

	Layer II_2	Layer II_3
Layer II_2	(1,1,1)	(6/5,2,27/10)
	(1,1,1)	(2/5,1,17/10)
	(1,1,1)	(7/5,2,13/5)
	(1,1,1)	(13/10,2,13/5)
	(1,1,1)	(3/10,1,8/5)
Layer II_3	(10/27,1/2,5/6)	(1,1,1)
	(10/17,1,5/2)	(1,1,1)
	(5/13,1/2,5/7)	(1,1,1)
	(5/13,1/2,10/13)	(1,1,1)
	(5/8,1,10/3)	(1,1,1)

Evaluation means of layer II_2 & II_3:

$$R^{(II)}=\begin{bmatrix}(1,1,1) & (0.920,1.600,2.240)\\(0.471,0.700,1.630) & (1,1,1)\end{bmatrix}$$

$$M^{(II)}=\left[(1.920,2.600,3.240)\quad(1.471,1.700,2.630)\right]$$

By the formula (6) calculation criterion layer each index comprehensive importance:

$$M_{II_2}^{(II)}=(1.920,2.600,3.240)\otimes\left[\frac{1}{2.630+3.240},\frac{1}{2.600+1.700},\frac{1}{1.920+1.471}\right]=(0.327,0.605,0.956)$$

$$M_{II_3}^{(II)}=(1.471,1.700,2.630)\otimes\left[\frac{1}{2.630+3.240},\frac{1}{2.600+1.700},\frac{1}{1.920+1.471}\right]=(0.251,0.395,0.776)$$

According to the formula (7) (8) (9), d'(II_2)=1, d'(II_3)=0.682, according to the formula (10)(11)(12) have a level indicator layer the weight of each index value:

$$W^{(II)}=\left[1/(1+0.682),0.682/(1+0.682)\right]=(0.595,0.405)$$

At the same time it can be regarded as a child in criterion layer criterion layer index II_2 elements innervating the indexes of III_6, III_7, III_8, III_9 weight values for,

$$W^{(III_6,III_7,III_8,III_9)}=(0.246,0.253,0.247,0.254)$$

due to the criterion layer is not fully hierarchical structure, according to the formula (13)(14) can be obtained after correcting the criterion layer index (III_6, III_7, III_8, III_9, III_{10}) weight:

$$W'^{(III_6\sim III_{10})}=(0.117,0.120,0.117,0.121,0.081)$$

Normalized by

$$W''^{(III_6\sim III_{10})}=(0.210,0.216,0.211,0.217,0.145)$$

(2) Indexes Inspection Results

Let x be the daily constraint number, d_i^+、d_i^- (i=1,2, ⋯,5), respectively, be positive and negative deviation variable of each target. And set up facilities and environmental factors of the same priority levels, according to the formula (13) and table 4-1., Tokyo UTCC study model could be established as follows:

$$\min f = 0.210 \cdot d_1^+ + 0.216 \cdot d_2^+ + 0.211 \cdot d_3^+ + 0.217 \cdot d_4^+ + 0.145 \cdot d_5^-$$

$$\begin{cases} x \le 146206 \\ 1.2389 \cdot (x+12868000) \le 64487000 \\ 0.3144 \cdot (x+12868000) \le 6859500 \\ 0.4114 \cdot (x+12868000) \le 7658450 \\ 8.9296 \times 10^{-5} \cdot (x+12868000) \le 5435 \\ 1.4265 \times 10^{-10} \cdot (x+12868000) + d_1^- - d_1^+ = 0.04 \\ 1.4978 \times 10^{-9} \cdot (x+12868000) + d_2^- - d_2^+ = 0.04 \\ 2.1397 \times 10^{-9} \cdot (x+12868000) + d_3^- - d_3^+ = 0.06 \\ 1.6404 \times 10^{-9} \cdot (x+12868000) + d_4^- - d_4^+ = 0.1 \\ 9506.6081 \cdot (x+12868000) + d_5^- - d_5^+ = 1.0959 \times 10^{10} \\ d_i^+ \ge 0, \quad d_i^- \ge 0, \quad i = 1, 2, \cdots, 5 \end{cases}$$

By lingo software solution for x=146206, $f=1.5890 \times 10^{13}$.

(3) Conclusion and Discussion

The results can be seen that the Tokyo UTCC is the maximum by the city facilities in residential facilities limited, other resources elements relative to the accommodation element can have a greater load capacity.

The model gives the result and it does not follow that the Tokyo metropolitan tourism carrying capacity is a model of value, this is due to resource constraints modeling elements to choose and decide, accurate in a model under the limited conditions of accommodation for the condition to tourist carrying capacity of Tokyo is 146206 people/day. The number does not include one-day trip that without accommodation to Tokyo, while for other forms of tourism, tourist carrying capacity study is to change the corresponding constraint condition.

The example given is a point value, according to the example we can make a dynamic description to the total number of passenger capacity of the approximate model values by time series of Tokyo in 2008 – 2010. Compared with actual and model numerical value (Figure 4-1), it is easily to find the rate of deviation is mainly between 44.51% - 85.18%, average deviation rate is 57.45%, that is to say the maximum tourism carrying capacity is 57.45% higher than the actual number of tourists of Tokyo between year of 2008 and 2010 monthly.

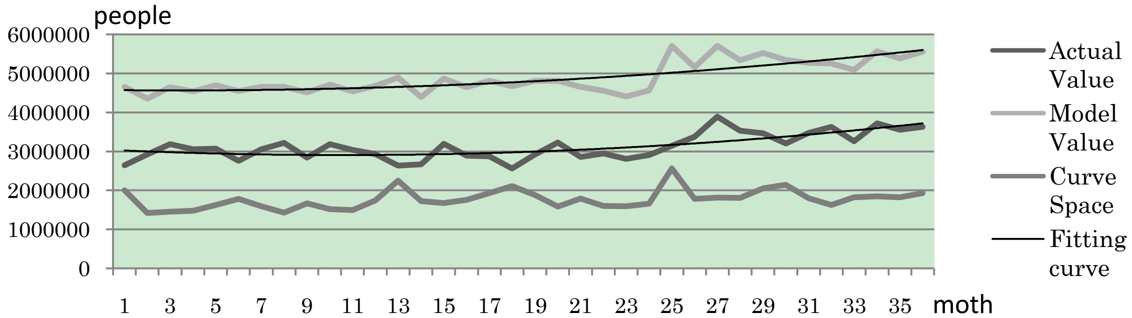


Fig.4-1. Model Value and Actual Value Curve of Tokyo monthly in 2008-2010

Model value and the actual value make curve fitting, according to the relevant parameters (Table 4-3) are chosen to do the two polynomial fitting curves.

Table 4-3 Model Value and Actual Value of Curve Fitting and Related Parameters

Curve Type	Model Value Curve Fitting	Judgment Coefficient R^2	Actual Value Curve Fitting	Judgment Coefficient R^2
Linear	$y=29328+4\times10^6$	0.582	$y=20034x+3\times10^6$	0.043
Logarithm	$y=28877\ln(x)+4\times10^6$	0.381	$y=18917\ln(x)+3\times10^6$	0.242
Index	$y=4\times10^6e^{0.005x}$	0.584	$y=3\times10^6e^{0.006x}$	0.389
Two Polynomial	$y=974.4x^2-6725x+5\times10^6$	0.638	$y=1268x^2-26884x+3\times10^6$	0.542
Power Function	$y=4\times10^6x^{0.057}$	0.385	$y=3\times10^6x^{0.059}$	0.236

The calculated curve fitting correlation coefficient r=0.798 express that model data fitting curve and the actual data fitting curve is positive correlation, description of city tourism carrying capacity and the actual number of tourists along with the time development trend showed strong positive consistency, tourism carrying capacity that increasing with time and the number of visitors increasing with time in the volume was positively consistency.

Two-wire spacing function,
$d(x)=-293.6x^2+20159x+2\times10^6$,
its one derivative and two derivative are as follows:

$$d'(x)=-587.2x+20159,\ d''(x)=-587.2$$

graph displayed on the curve is concave. And when x≤34.3, the curve process increasing process, then when x≥34.3 it appears descending trend, which reflect the reality that from 2008 January to 2010 October about this time, the gap between Tokyo UTCC and the actual number of tourists is increasing. This is relative to the Tokyo carrying tourist number for the actual number of tourists continued to decline, and this situation, after 2010 October, appeared exchange.

The two encirclement area function curve

$$S(x)=\int(-293.6x^2+20159x+2\times10^6)dx$$

for [0,36] range, the integral of

$$S(x)\Big|_0^{36}=\int_0^{36}(-293.6x^2+20159x+2\times10^6)dx$$
$$=9.33\times10^{10}$$

integral value is described in [0,36] interval model value curve function and greater than the actual value curve function, and from 2008 January to 2010 December, UTCC of Tokyo is greater than the actual number. The two curve in [0,36] range out of focus, so that there is no real value function and value function for a model of the phase offset of the situation, model value curve function value is always the actual value curve function value, namely the tourism carrying capacity is always greater than the actual total number of visitors. Integral numerical representation from 2008 January to 2010 December, urban tourism carrying capacity is greater than the total number of visitors, i.e. relative to the Tokyo Metropolitan Tourism Carrying Capacity of tourist total gap number.

Because of insufficient data, examples can only be based on 2008 – 2010 on both the number of visitors to do analysis, from the actual situation, due to the seasonal tourism activities, if it can be continuous long time with the same quarter data or data analysis, curve fitting, the effect will be better.

5. Further Reflection

This study established the city tourism carrying capacity study model; although this model to the limit of resource elements either qualitative or quantitative investigation provides an inclusive platform, but still have the following problems need further research:

(1) For different states of resource constraints between the elements, the relationship between the model results and the spreading effect still need further investigation.

(2) For the qualitative constraint resource conditions (such as urban tourism social capacity, political force) inspection method remains to be further studied.

(3) Because of the actual count data availability limitations, research only use the government statistical data of some indicators as constraints for example, which is affected by many factors the city tourism carrying capacity research is not enough, model database either from the model predictive or from results the verifiability is necessary.

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$$r = \frac{\sum_{i=1}^{n}(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_{i=1}^{n}(x_i - \bar{x})^2}\sqrt{\sum_{i=1}^{n}(y_i - \bar{y})^2}},$$

x_i, y_i for the model value and actual value