Doctor's Thesis

Study on Urban Tourism Carrying Capacity

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The past three years in Toyo University have been the most challenging and rewarding time of my life. I will fondly remember many things from this exciting period and never forget those who have helped me accomplish this lifelong goal.

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I would also like to thank my family members. I look forward to focusing my efforts and spending more quality time with them. They inspire me to be a better person, husband and educator. Thank you for your patience and love during this time.

Last but not the least, I will treasure and will continue to be grateful to people who appreciated me for my work and motivated me throughout my project. I am making this project not only for marks but to also increase my knowledge.

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ABSTRACT

It was more than 70 years since the end of the World War II. During this period, though there is still war exist in some area, "peace" and "development" have been two major themes in human society overall. The society is no longer experience the global hit such as the War II. Under this background, the tourism industry has experienced a rapid development for a long time.

However, boom in tourism brings economic benefits as well as the problems for the region. Millions of tourists have caused tremendous pressure to the urban in terms of the physical (transportation, water & electronic resource, etc.) and nonphysical (society, culture, belief of the residents, etc.) elements.

According to this situation, the article does a preliminary research on the carrying capacity of the urban tourism, which aims to evaluate the capacity from both tangible and intangible views by different models. Tangible elements (named as physical elements in this study) in the urban system mainly refer to the elements that can be evaluated by quantitative methods. And the data can be collected by statistic data published by government with a high credibility. While intangible ones (named as nonphysical elements) refer to the elements which is difficult to be evaluated directly. And the required data are always collected by investigation.

For the evaluation of the physical elements, research method combining FAHP (fuzzy analytic hierarchy process) with MOM (multi objective optimization method) to establish the study model in this dissertation. Application research takes Tokyo and Osaka as examples to do applicative study. Results of daily tourism carrying capacity of two cities are 150,000 peolple/day and 60,000 people/day in Tokyo and Osaka respectively. Further analysis on fitting equation of the two cities is done with three parameters, and makes the data prediction for the future period of Jul. 2012–Dec.2013.

For the nonphysical elements, SRS (Stratified Random Sampling) is combined with FAHP method to do the evaluation. The application study takes Bunkyo District (Tokyo) as an example. Result of the social-psychological carrying capacity of the residents shows a positive attitude to the tourist with a value of (0.41, 0.56, 0.69) overall.

This study tries to combine the two evaluation methods together by modifying the physical result with nonphysical result and takes Bunkyo District as an example. The modified result of the UTCC shows a growth tendency with the increasing of the tourist number, which is consistent to the welcome attitude of the resident to the tourist.

Further studies such as the appropriate range, mutual influences of different elements and their impact, non-physical elements' content and its research methods, etc. have been discussed at the end of the thesis.

Keywords
UTCC (Urban Tourism Carrying Capacity); FAHP (Fuzzy Analytic Hierarchy Process); MOM (Multi-objective Optimization Method); SRS (Stratified Random Sampling); Application Study.

CONTENTS

Chapter 1

Introduction of the Study

1.1 Introduction

(1) Acceleration of World Urbanization and Increase of World Tourist Arrivals under the Background of Peace and Development

Within over half a century after the World War II, the human society kept stable developing and did not experience global-scale social civilization destruction as in World War II.

Although the countries, in different historical periods, experienced more or less local obstacles of social civilization progress caused by social development and contradictions, the two major themes, "peace" and "development", have been much popularized for the development of human society worldwide.

Under this background, the industrial development has accelerated the urbanization worldwide, and the development of economy and informationization have promoted the process of globalization (Figure 1-1.).

	1950	1970	2011	2030	2050
World Population	2530000000	3700000000	6970000000	8320000000	9310000000
Urban Population	750000000	1350000000	3630000000	4980000000	6250000000
Rural Population	1790000000	2340000000	3340000000	3340000000	3050000000
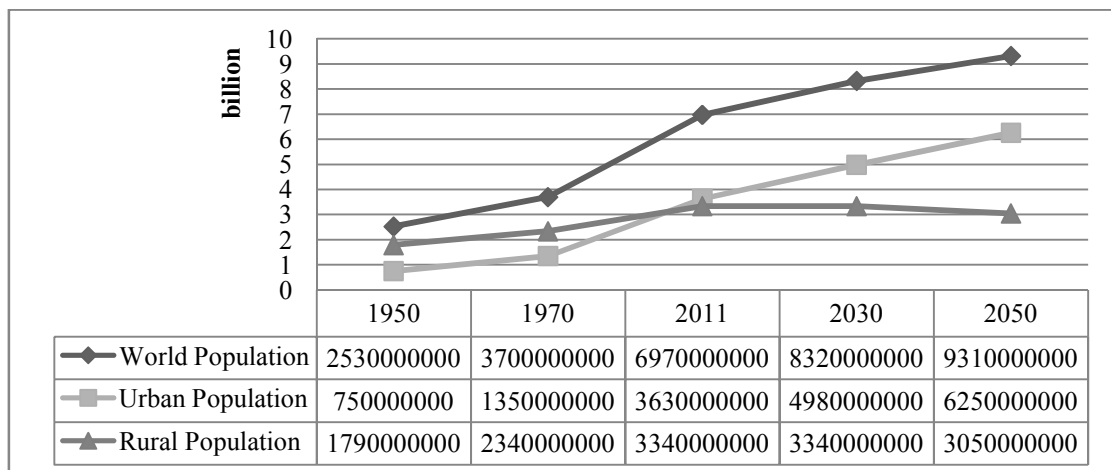
Figure 1-1. Total Urban and Rural Populations, Selected Period, 1950-2050

Source: World Urbanization Prospects: the 2011 Revision, United Nations, New York

In human socialization and the process of globalization, leisure and recreation are gradually heavily demanded in peaceful times, and this demand changes with the passing by of times and constant expansion of human activities, thus the global tourism industry experiences rapid development.

According to UNWTO data, by the end of 2010, the world tourist arrivals had grown from 25,280,000 in 1950 to 940,000,000 (Figure 1-2.), meaning an increase of about 37 times, and the international tourism revenues had grown from $2,100,000,000 to $919,000,000,000 (Figure 1-3.), meaning an increase of about 437 times.

Figure 1-2. World Tourist Arrivals, Selected Period, 1950-2010

Source: World Tourism Organization (UNTWO)

Figure 1-3. International Tourism Profits, Selected Period, 1950-2010

Source: World Tourism Organization (UNTWO)
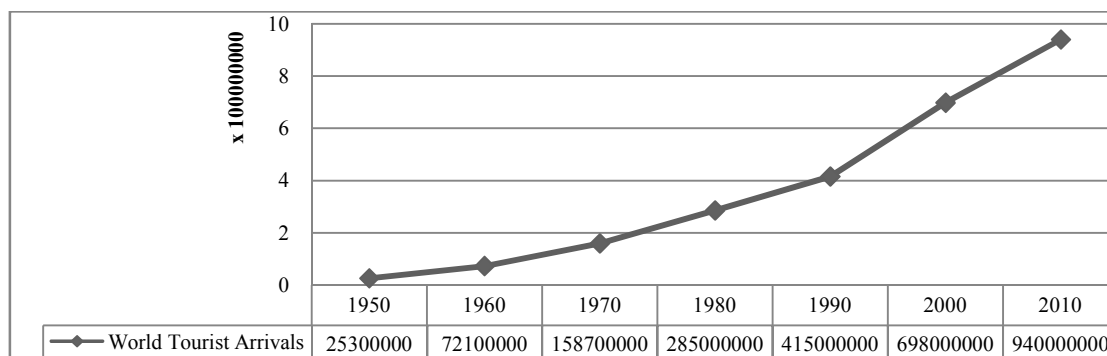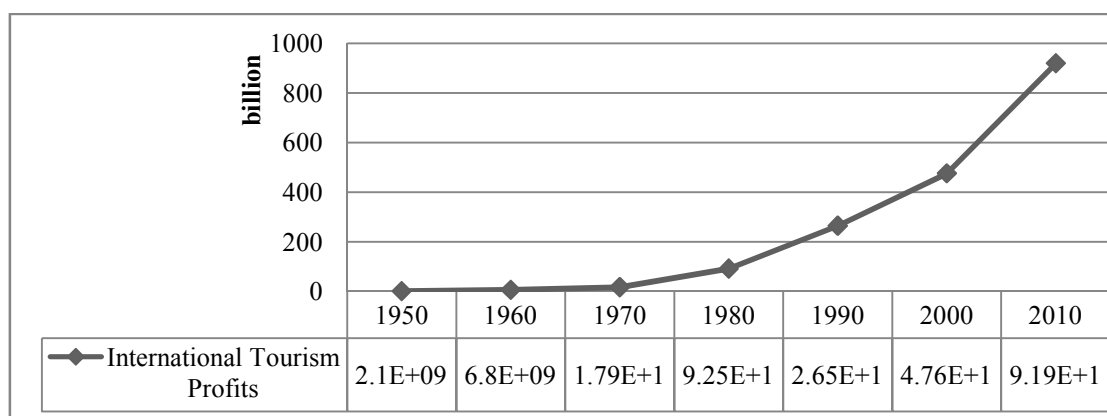
(2) Trend of Tourist Arrivals' Flowing into Urban

"Urban", as rallying site of local human society civilization, has become popular tourism destination.

According to data from UNWTO, tourist number of 100 most popular cities in 2010 reached 358,209,000 (Table 1-1.), accounting for 38.12% of the total population of world tourism (940 million). These figures can show that tourists worldwide tend to going to cities in general.

Table 1-1. Top-100 City Destinations Ranking, 2010

Rank	City	Arrivals (thousand)	Rank	City	Arrivals (thousand)	Rank	City	Arrivals (thousand)
1	Hong Kong	19,973	35	San Francisco	2,929	69	São Paulo	1,825
2	Singapore	18,297	36	Edirne	2,912	70	Agra	1,813
3	London	14,706	37	Toronto	2,879	71	Jaipur	1,777
4	Macau	13,098	38	Berlin	2,872	72	Johannesburg	1,771
5	Bangkok	10,984	39	Seoul	2,809	73	Chiang Mai	1,769
6	Antalya	10,641	40	Chennai	2,785	74	Shenzhen	1,749
7	Kuala Lumpur	10,351	41	Guangzhou	2,687	75	Christchurch	1,744
8	New York City	8,961	42	Sydney	2,610	76	Hangzhou	1,744

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9	Paris	8,176	43	Budapest	2,606	77	Athens	1,733
10	Istanbul	8,124	44	Denpasar	2,600	78	Venice	1,695
11	Dubai	7,752	45	Sharm el Sheikh	2,558	79	Florence	1,690
12	Mecca	6,122	46	Buenos Aires	2,509	80	Honolulu	1,666
13	Miami	6,003	47	St Petersburg	2,500	81	Abu Dhabi	1,624
14	Rome	5,620	48	Warsaw	2,450	82	Halong	1,581
15	Shanghai	5,397	49	Damascus	2,436	83	Washington DC	1,569
16	Barcelona	5,160	50	Ho Chi Minh	2,435	84	Burgas	1,535
17	Las Vegas	5,130	51	Cancún	2,434	85	Riyadh	1,512
18	Cairo	4,998	52	Delhi	2,350	86	Varna	1,501
19	Beijing	4,901	53	Brussels	2,235	87	Cape Town	1,486
20	Los Angeles	4,550	54	Mumbai	2,195	88	Melbourne	1,466
21	Pattaya	4,430	55	Bucharest	2,136	89	Hurghada	1,459
22	Amsterdam	4,021	56	Aleppo	2,116	90	Edinburgh	1,404
23	Tokyo	3,817	57	Munich	2,053	91	Minsk	1,398
24	Prague	3,758	58	Marrakech	2,028	92	Suzhou	1,379
25	Moscow	3,740	59	Mexico City	2,028	93	Zurich	1,378
26	Phuket	3,612	60	Jakarta	2,000	94	Sharjah	1,335
27	Dublin	3,587	61	Vancouver	1,951	95	Kolkatta	1,313
28	Punta Cana	3,521	62	Auckland	1,950	96	Algiers	1,312
29	Vienna	3,520	63	Rio de Janeiro	1,929	97	Chicago	1,300
30	Madrid	3,402	64	Lima	1,925	98	Krabi	1,291
31	Kiev	3,343	65	Milan	1,910	99	Queenstown	1,265
32	Orlando	3,277	66	Seattle	1,893	100	Manila	1,250
33	Taipei	3,224	67	Lisbon	1,881			
34	Mugla	3,211	68	East Province	1,877			
Summary(thousand)					358,209			

Source: Euromonitor International, 2012

As for the condition nationwide, with the data of international tourists in United States, China and Japan as examples: the number of inbound tourists to the United States in 2010 reached 59,792,616, and that in 20 cities reached 33,270,000, accounting for 55.64% of the total number (Table 1-2.).

The number of inbound tourists to China in 2010 arrived 134,000,000 (data from China National Tourism Bureau-CNTB), and that to 28 main cities amounted to 56,779,992, accounting for 42.37% of the total number (Table 1-3.); the number of tourists to Japan nationwide in 2006 reached 2,817,570,000 (according to Tourism Bureau of Japan), and that to 15 designated cities and a special area amounted to 1,264,152,000, accounting for 44.87% of the total (Table 1-4.).

No	City	Arrivals	No	City	Arrivals	No	City	Arrivals
	Table 1-2. Top States and Cities Visited by Overseas Travelers of USA, 2010			**Table 1-3. International Tourists by Major Cities of China, Jan.-Dec., 2010**			**Table 1-4. Tourists by Ordinance-Designated Cities & Tokyo Wards Area of Japan, Jan.-Dec., 2006**	
1	New York City, NY	8462000	1	Beijing	4900661	1	the 23 wards of Tokyo	376981000
2	Los Angeles, CA	3348000	2	Tianjin	1660682	2	Sapporo	14100000
3	Miami, FL	3111000	3	Shenyang	550313	3	Sendai	15290000
4	Orlando, FL	2715000	4	Dalian	1166020	4	Saitama	21170000
5	San Francisco, CA	2636000	5	Changchun	249824	5	Chiba	17300000
6	Las Vegas, NV	2425000	6	Harbin	263609	6	Yokohama	39960000
7	Washington, DC	1740000	7	Shanghai	7337216	7	Kawasaki	12970000
8	Oahu/Honolulu, HI	1634000	8	Nanjing	1308791	8	Shizuoka	23630000
9	Boston, MA	1186000	9	Wuxi	791592	9	Nagoya	30740000
10	Chicago, IL	1134000	10	Suzhou	2075299	10	Kyoto	48390000
11	San Diego, CA	765000	11	Hangzhou	2757147	11	Osaka	104050000
12	Atlanta, GA	712000	12	Ningbo	951680	12	Sakai	5380000
13	Philadelphia, PA	633000	13	Huangshan	1050301	13	Kobe	29200000
14	Flagstaff, AZ	501000	14	Xiamen	1551865	14	Hiroshima	10280000
15	Seattle, WA	475000	15	Jinan	230985	15	Fukuoka	16700000
16	Houston, TX	448000	16	Qingdao	1080511	16	Kitakyushu	16440000
17	Anaheim-Santa Ana	369000	17	Wuhan	927903		Count	1264152000
18	Tampa/St. Petersburg, FL	343000	18	Guangzhou	8147900			
19	Dallas-Plano-Irving, TX	343000	19	Shenzhen	10206000			
20	San Jose, CA	290000	20	Zhuhai	3251400			
	Count	33270000	21	Zhongshan	480600			

Table 1-2 Source: U.S. Department of Commerce, ITA, Office of Travel and Tourism Industries. Release Date: May 2011

No	City	Arrivals
22	Guilin	1486202
23	Haikou	132877
24	Sanya	415939
25	Chongqing	1370231
26	Chengdu	731993
27	Kunming	860632
28	Xi'an	841819
	Count	56779992

Table 1-3 Sources: The Yearbook of China Tourism Statistics, 2010

Table 1-4 Sources:
Data book of tourists and tourists resorts in Japan. (2006). Archives Press.
Databook of Tourists and Tourists Resorts in Japan. (2006). Japan Travel and Tourism Association.
国際観光白書. (2006). Japan National Tourism Organization.

Therefore, it is demonstrated that, at the national level, although the statistical calibers are different, the number of tourists tending to cities occupies higher proportion in the total number of visitors nationwide. Accordingly, it is necessary to study the cities much more attracting for tourists.

(3) Impact of Tourist Arrivals on Urban

The large number of tourists to the urban will cause much impact, especially that the concentrated and excessive use within short period of time can cause greater impact to it.

In many cities, the overall image of tourism destination has declined due to the influx of tourists which led to the decline of service quality, environmental damage,

cultural relic's damage, deterioration of public security, etc., and even led to the mass distrust between tourists and residents.

Therefore, it is essential to study urban tourism carrying capacity (UTCC) so as to avoid or control the above poor situation, which is also the starting point of this study.

1.2 Background of the study

(1) Reality Background

In reality, with the development of economic and transportation, more and more people are choosing an urban area as tourism destination for leisure, shopping, entertainment, history learning and so on for vacation. The cities, overcrowded by tourists, will experience great pressure in various resources especially in holidays.

Figure 1-4 reflects the daily number of visitors in "Golden Week" and usual days in China. According to the figure, the number of tourists during holidays is much higher than that in usual days could be seen easily.

As for the data of 2001 - 2010, in 2001, the number of tourists in usual days was about 2,390,000, and this number reached 6,130,000 in 2010, meaning an increase of about 2.6 times.

At the same time, the daily amount in "Golden Week" increased from 9,140,000 in 2001 to 36,290,000 in 2010, indicating an increase of about 4 times; while the ratio of the daily number in "Golden Week" to that in usual days rose from 3.8 up to about 6.
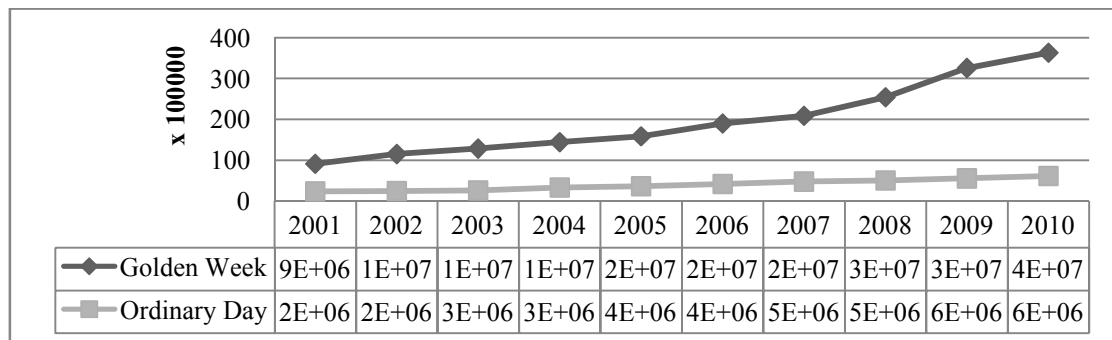

x 100000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Golden Week	9E+06	1E+07	1E+07	1E+07	2E+07	2E+07	2E+07	3E+07	3E+07	4E+07
Ordinary Day	2E+06	2E+06	3E+06	3E+06	4E+06	4E+06	5E+06	5E+06	6E+06	6E+06

Figure 1-4. International Tourism Profits, Selected Period, 1950-2010

Source: data from Statistics of CNTA (http://www.cnta.com/)

Rapid growth of the number of tourists also brings about many problems, such as the deterioration of social order, decrease of tourist satisfaction, etc.

With China Beijing as an example, in the Golden Week (1st-7th, Oct. 2010), the number of visitors to the city has reached 9,300,000, showing additional 22% than that in the previous year. During the Golden Week, the number of criminal cases increased 12% over the same period last year (data from the National Holiday Office and China National Tourism Administration).

In addition, in 2010, Shanghai held World Exhibition from May 1st to October 31st, the number of visitors reached 73,080,000 in total, to be the largest ever number in exhibition history. The average daily number of visitors was hundreds of thousands, especially that in the last month, it roared up to 1,200,000 a day, sometimes tourists had to wait for 6 or 7 hours, leading to many complaints (data from Shanghai Municipal Tourism Administration).

The overcrowded tourists in some region of a city will also affect the city's atmospheric environment, which can be explained by the studies of Miyake Masahiko (2010), a Japanese scholar who takes Angkor Monuments in Kampuchea area as the object of study to research the influence of the number of local tourists on atmospheric environment.

The results show that activities of the tourists will affect the atmospheric environment surrounding tourism area, which is mainly displayed that the concentration of TSP (Figure 1-5.), particulate matter, and polycyclic aromatic compounds PAHs (Figure 1-6.) will rise with the increase of the tourist number.
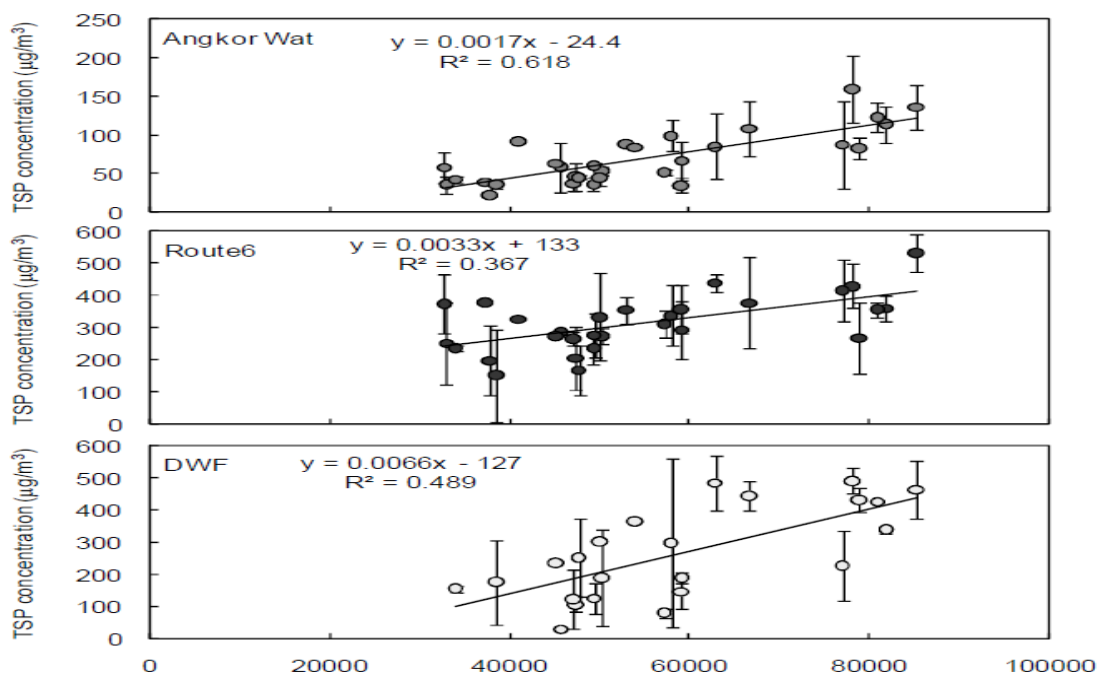

Figure 1-5. Relationship of the Average Monthly TSP Concentration and Number of Inbound Tourists of Shemuiriapu Airport, Selected Period, 2006-2008
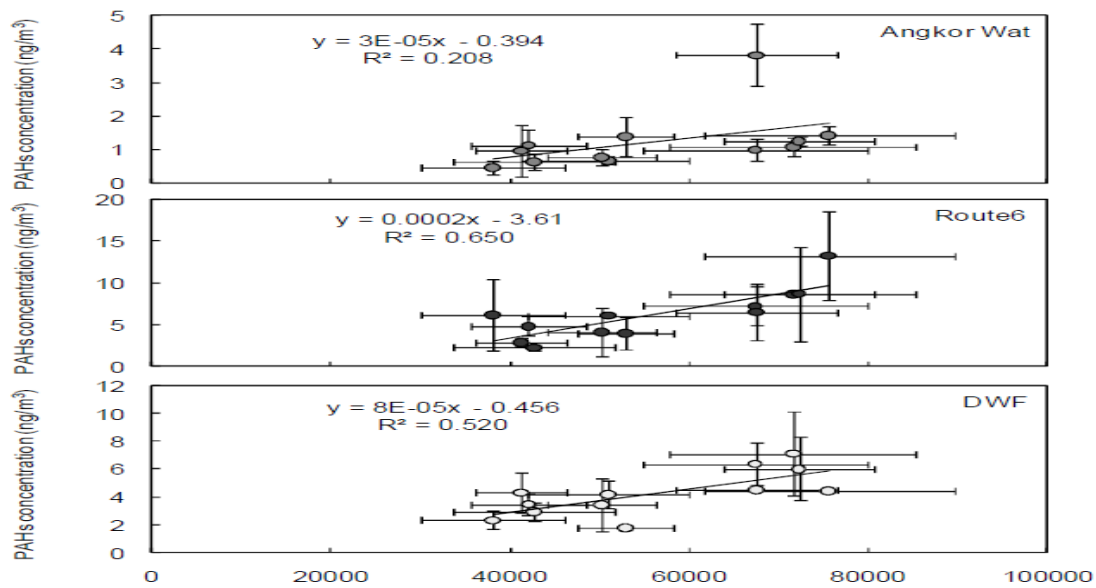
Figure 1-6. Relationship of the Average Monthly PAHs Concentration and Number of Inbound Tourists of Shemuiriapu Airport, Selected Period, 2006-2008

Souce: Fig. 1-5 and Fig. 1-6 are both according to the data of Pro. Miyake's study on Angkor monument area (No. 19404003), Kanezawa University.

Urban tourism development is closely related with other industries, the tourism industry should be rapidly and harmoniously developed according to capacity of other industries. Whichever industry that once is beyond the carrying capacity of tourism industry will lead to various social and environmental problems, and even the industry vicious chain reactions.

Therefore, it is realistically necessary to study the UTCC.

(2) Academic Background

The academic background of the study is on the source of unceasing expansion in tourism research. In reality, the travel range expansion has also led to the tourism research object expanding. However, a single attribute and its object inspection has been unable to meet the needs of the actual development for tourism destination study.

From macro points of view, the current theories of carrying capacity are mainly applied into biology, demography, applied ecology and human ecology (Figure 1-7.)[1].

As for the specific application, the current theories can be divided into carrying capacity of natural resources or environment to population, carrying capacity of ecological environment to specific living things and entertainment tourist carrying capacity (Figure 1-8.)[2].

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[1] Seidl, I., Tisdell, C. A. (1999). Carrying capacity reconsidered: from Malthus' population theory to cultural carrying capacity. *Ecological Economics*, 31, 395-408.
[2] Ruan Benqing, Liang Ruiju, Wang Hao, et al. (2001). *Water Resources Management in River Basin*. Sciences Press, 156-200.
   Guo Xiurui, Mao Xianqiang.(2000). Review of land carrying capacity calculating methods in China. *Progress in Earth Science*, 15(6), 705-711.

According to different research methods, specific empirical carrying capacity, general empirical capacity and theoretical carrying capacity can be summarized (Figure 1-9.)[3].
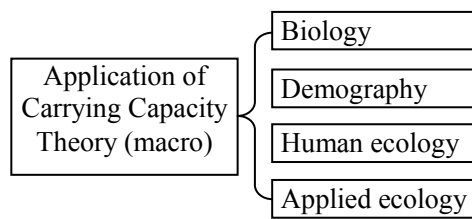
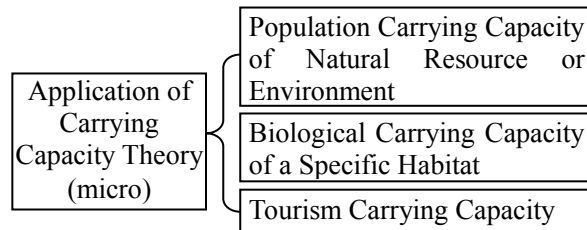**Figure 1-7. Application of Carrying Capacity Theory (Macro)**

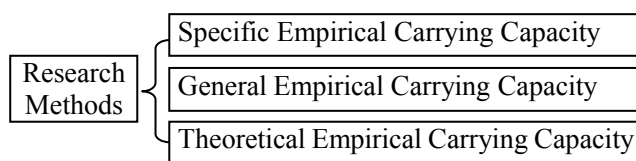**Figure 1-8. Application of Carrying Capacity Theory (Micro)**

Figure 1-9. Research Methods of Carrying Capacity Theory

In fact, the research of UTCC is developed along with the accelerated urbanization in human society. The increasing development of urbanization leads to the public's concentrated demand of recreation within short period of time (such as vacations). The phenomenon caused people distribution in short time to wide range, and followed by malignant utilization of tangible and intangible resources in cities, so that the original balance of city system was destroyed.

The urban tangible tourism resources include ecological resources, environmental resources, infrastructure resources, all kinds of enterprises and their products, human resources and the like all of which physically restrict the UTCC.

Some resource, which is damaged due to some reasons and reduces its carrying capacity, will directly lead to usually violent exclusion effect. And the destruction to urban system can play effect in a short period of time and quickly reach to the most serious result. However, it will usually not last for long, and will gradually recover along with the passage of time or the change of resources due to external influence, which essentially reflects the "imbalances" of supply and demand of resources within a short time.

The intangible elements contain the social psychological factors of city residents (such as the psychological carrying capacity to the urban tourism), urban political and economic factors (including international political influence, national and city policy orientation, economic conditions, etc.), urban tourism service quality, the degree of opening of original customs and culture, all of which invisibly affect the city residents and tourists.

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[3] Lockwood, D. R. (1998). Reconsidering carrying capacity. (http://www.itd.ucdavis.edu/～dale/studies/carrying.html.)

Compared with tangible physical factors, intangible spiritual elements are more easily to form negative additive effect and butterfly effect. The former tends to outbreak after certain concentrated accumulation, triggering mass distrust; the latter will extent the former to the whole urban tourism system, followed by damage to the overall image of tourism site.

Negative effect is usually accumulated to a certain extent and outbreaks with group consensus triggered by a small chance, leading to large-scale influence, and this poor effect will last long both before and after outbreak.

Then, it appears the research with a wide range, multiple attribute set for the conditions of the tourism carrying capacity.

The present studies mainly focus on definition and measurement of the carrying capacity of physical natural environment, which meaning more attention to physical factors and relative neglect of social factors especially the carrying capacity of social system.

Tourism activity is essentially an intercultural communication featured in "subject-object" interaction, and the effect of psychosocial factors on tourism carrying capacity becomes more prominent. Therefore, it will be especially critical to take into social factors so as to study open social system such as the UTCC.

In addition, further studies on the elements of existing capacity, the index system and the research methods are needed from integrated and general perspectives so as to investigate and evaluate the carrying capacity.

Previous researches failed to focus on general open subjects with multidimensional attributes due to their different perspectives, research ideas and methods limited by different professions, geographical features and cultures. But in the relevant literature research, there are only a few case studies from single perspective such as ecology, environmental science or other disciplines to do the research in the city of U.S., Britain or some other developed countries. For Asian cities, it still needs further study.

This research attempts to integrate the exiting research to explore a new perspective to study the carrying capacity with multi-attributes.

1.3 Purpose of the Study

Urban area, as a representative region of concentrated human social civilization, is attracting more and more people, and the urban residents worldwide are also growing.

More and more large groups of urban people are drawing tremendous pressure to the tangible and intangible urban resources in a short period of time via leisure activities. In addition, urban as the travel destination, is attracting increasing more external tourist groups. Inner and outer huge crowd causes large-scale people concentration and distribution in urban tourism within short time, which is easy to destroy the balance of original city system and lead to malignant utilization of urban resource elements.

This paper aims to better define, investigate and evaluate UTCC, and accordingly make practical suggestions.

Based on the above situation, this paper attempts to construct the UTCC theory and study model from the overall and systematic perspectives and does the application research with specific areas.

The main objectives of the study are as follows:

(1) Based on summary of the existing researches, to define UTCC and related concepts, clarify the research content about UTCC and investigation factors, and establish the index system according to the factors.

① Based on the researches on carrying capacity and UTCC, this study aims to analyze the characteristics and connotation of UTCC.

② Analyze factors affecting the UTCC from four aspects, including tourism facilities, ecological environment, social culture, politics and economy, and further analyze the connotation of influential factors.

③ Establish index system according to the influencing factors.

(2) To establish model for investigation according to UTCC index system, and carry out research on characteristics and functions of the model.

① To classify the influencing factors into groups of physical investigation and non-physical investigation according to their characteristics and set measurement index system.

② To construct appropriate measurement model embracing different attributes. The carrying capacity of physical factors can be analyzed with MOM (multi-objective optimization) combined with FAHP, and that of non-physical factors can be analyzed with SRS combined with FAHP.

(3) The application study of the model will conducted with cities as examples.

① Carrying capacity of physical factors is investigated with Tokyo and Osaka as examples, based on the statistical data from governments.

② Carrying capacity of non-physical factors is investigated with Bunkyo District in Tokyo as an example, via questionnaire survey, to find out the social psychological carrying capacity of residents in Bunkyo District to tourists.

③ According to the investigation results from both physical and non-physical aspects, comprehensive value of UTCC will attempt to be given with Bunkyo District as an example.

(4) To make practical suggestions, from physical and non-physical level, for future tourism planning according to the investigation results.
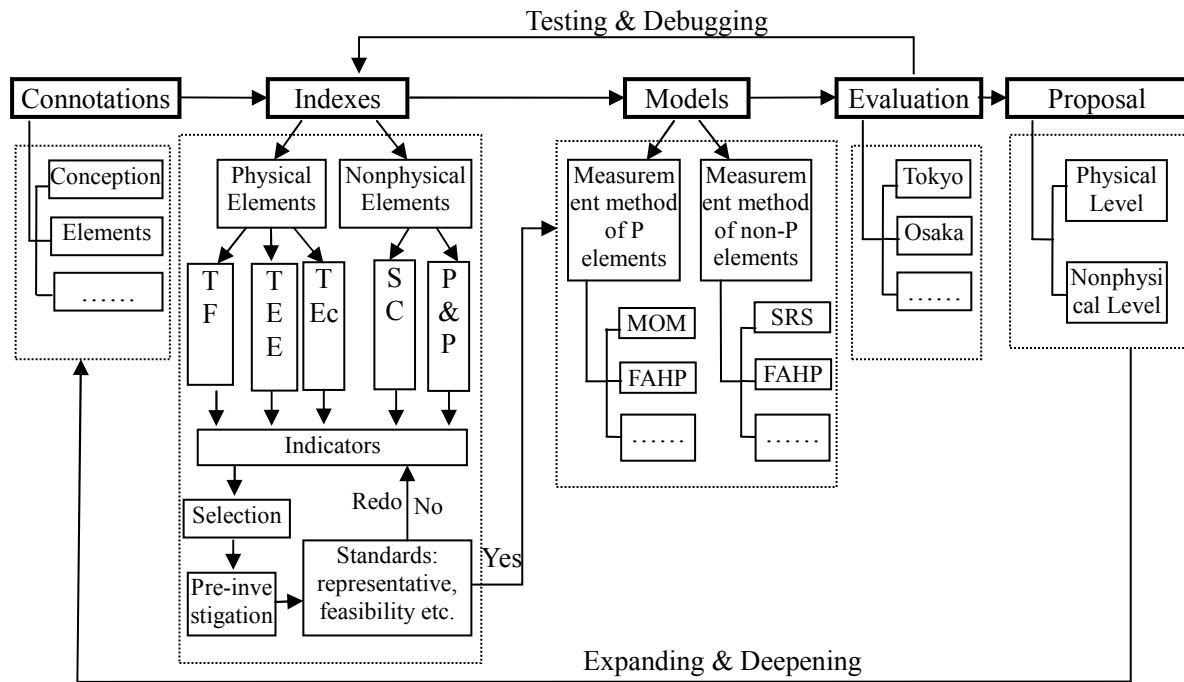
Research train of thought is as Figure 1-10.

Figure 1-10. Research Train of Thought

Notes:
TF: Tourism Facilities   TEE: Tourism Ecological Environment   TEc: Tourism Economy
SC: Social Culture   P&P: Politics & Policy

1.4 Methods of Study

Normative research idea of this study conforms to "connotation system -- index system -- model simulation test -- advice proposal". Starting from the characteristics of the closed and open environment of the carrying capacity, the study analyzed the meaning and influencing factors of UTCC.

According to the elements of the establishment of evaluation index system and evaluation model, simulation test on the specific city, test results for different objects on the basis of comparative study. Finally, expand and deepen the connotation of UTCC, the adaptability of the index system and evaluation model analysis through the cross-cultural analysis and discussion.

The following research methods are adopted:

(1) Literature research. This method is mainly adopted to clarify the concept of UTCC, research contents & elements, and establish the evaluation index system & model, based on inheriting and drawing the existing research results.

(2) Surveys. Data for model establishment are collected via network, phone, questionnaire and interview. The former two means are mainly used to collect data for quantitative analysis of the physical factors of UTCC, while the latter two means are mainly used to collect data for qualitative analysis of non-physical factors of UTCC.

(3) Combination of qualitative analysis and quantitative analysis. The physical factors are quantitatively analyzed with FAHP and MOM; time sequence and regression analysis via the model are used to simulate and forecast the future situation. The carrying capacity of non physical factors is evaluated with SRS and FAHP. The study also gives the corresponding algorithm for combined application of the two methods.

1.5 Originality

(1) The theoretical innovation: The research presents the concept of UTCC, and does an analysis of its meaning and elements, constructs an evaluation model the application study of it.

(2) Innovation of research framework: This research is different from previous researches on the carrying capacity with a single tourism site and its single physical factor as object, then overall and systematically integrates physical and non-physical influencing factors to study UTCC.

(3) Innovation of research methods: This study on UTCC takes cities as subject of practice in macroscopic view, which is a general study model in study of tourism field. As for research methods, mathematics and computer application are combined, to reveal different influence degrees of different elements and different aspects of the same element.

FAHP is combined with MOM, SRS and FAHP are combined to qualitatively and quantitatively research of UTCC. As well, the qualitative analysis is adopted to correct quantitative results as an attempt in this study.

(4) Innovation of conclusions: This study, starting from the objective environment development trend, proposes the complexity of urban open system, reveals the multi-level factors to impact UTCC, and concludes that the factors are combined to affect urban system.

1.6 Construction of the Dissertation

This paper includes 6 chapters:

Chapter One is the introduction of the study. It mainly introduced the overall framework of the UTCC study which includes the research summary, realistic and academic background, research purpose, methods, innovations and layout.

Chapter Two is literature review of the study. The origins of research on carrying capacity, the research development and the research status are explained to review the existing research results in Europe, the United States, Japan and China which are discussed from four aspects, including ecology, sociology, economics and political science. In addition, the shortcomings and development direction of existing research are also discussed in this chapter.

Chapter Three defines UTCC and builds required theories. After literatures reviews, the definition and meanings of UTCC are offered, and the corresponding research system is constructed from three aspects, including the Urban facilities-environmental TCC, Urban social-cultural TCC, and Urban political-economic TCC. The influencing elements are classified as physical and non-physical ones and the embraced specific indexes in each element are discussed, so as finally to establish evaluation index system of UTCC.

Chapter Four models UTCC. Model of UTCC is divided into three parts: the establishment of the index system according to the relationship of increasing layer from the three aspects of UTCC, research method of the physical and non-physical elements combining FAHP (fuzzy analytic hierarchy process) with MOM (multi objective optimization method) and SRS with FAHP to establish the study model, and the functions of the model, evaluated by three parameters r (curve fitting parameter), d (line spacing of the fitting curves) and S (surround area of the fitting curves).

Chapter Five is the application study of the UTCC model with specific cities. The physical indexes of tourism carrying capacity are studied with Tokyo and Osaka as examples, according to statistical data released by governments. The non-physical indexes are analyzed with Bunkyo District, Tokyo as example. Questionnaire surveys are carried out to collect the data needed so as to evaluate the social psychological carrying capacity of residents in Bunkyo District to tourist activities. This chapter finally puts forward to combining physical and non physical elements for investigation, and works out the comprehensive value of tourism carrying capacity with Bunkyo District as example after comprehensive investigation.

Chapter Six contains conclusions, development direction and suggestions. The conclusions summarize the practical and theoretical meaning of research on UTCC. The development direction describes theoretical system construction, index selection and classification, selection of evaluation methods for different indexes, the interaction degree and effect of different factors and indexes, applicability of model in different cultures (regions).

Chapter 2
Review of Literature

2.1 Origination and Development of UTCC Theory

Origination

Urban tourism carrying capacity derives from the study of tourism carrying capacity, which originates from the concept of carrying capacity. As a result, the origin of tourism carrying capacity can be dated back to the origin of carrying capacity.

The origin of carrying capacity differs in time based on the various perspectives of disciplines.

From the perspective of applied ecology, Bartels (1993)[4] dated the origin of carrying capacity back to the American Yearbook of Agriculture in 1906; Merriam-Webster Dictionary (2012)[5] traced it back to 1889 from the point of view of population biology; Malthus (1798)[6] laid the foundation for the origin of carrying capacity from the perspective of demography in his work *Essay on the principle of population* published in 1798. Later Verhulst (1838)[7] and Pearl et al. (1920)[8] pointed out respectively and independently the Logistic equation which provided the mathematical expression formula for the theory of carrying capacity; Wagar (1964)[9] believed that people had been aware of the limitation of land carrying capacity since prehistoric times and it was usually caused by the shortage of food as mentioned in many ancient books such as *The Old Testament*. Haddon (1927)[10] had once proved that the human migration is "mostly caused by the shortage of food or excessive population"; some scholars (Chen Chunsheng, 1987)[11] even dated the origin of carrying capacity back to the ancient Greek times. Most modern studies of carrying capacity are more inclined to the origin of ecology.

Development

Based on the progress and the quantity of relevant studies, the process of the carrying capacity concept applied in the tourism field can be divided into four stages:

The first stage was the period before 1930s when carrying capacity was mainly applied in the fields of ecology and demography. The major focuses of demography

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[4] Bartels, G. B., Norton, B. E., Perrier, G. K. (1993). *An examination of the carrying capacity concept.* In R. H. Behnke Jr., I. Scooners, and C. Kerven (Eds.)*, Range ecology at disequilibrium*. London: Overseas Development Institute, 89-103.

[5] *Merriam-Webster's Collegiate Dictionary (11th ed.)*. (2012). Merriam Webster, 190.

[6] Thomas M. (1978). *Essay on the principle of population.* London: J. Johnson, 396.

[7] Verhulst, P. F. (1838). Notice sur la loique la population suit dans son accroissement. *Correspondance mathematiue et physique*, 10, 113-121.

[8] Pearl, R., Reed, L. J. (1920). On the rate of growth of the population of the United States since 1790 and its mathematical representation. *Proceeding of the National Academy of Sciences,* 6(6), 275-288.

[9] Wagar, J. A. (1964). The carrying capacity of wild lands for recreation. *Forest Science Monographs,* 7, 1-23.

[10] Haddon, A. C. (1927). *The wanderings of peoples*. London: Cambridge University Press, 124.

[11] 陈春生.(1987). 环境容量收容力分析与都市成长管理之研究-以台北都会区水资源个案为例.国立台湾大学建筑与城乡研究学报, 3, 133-144.

were the pessimistic Malthusian theory of population and the mathematical model of population growth (Pearl et al., 1920)[12]; ecology mainly centered on applied ecology (Zhang Linbo et al.,2009)[13], including the maximum grazing capacity management of livestock farms (Hadwen et al., 1922)[14], the validation of the mathematical models of demography which were applied in the field of ecology (Pearl, 1927)[15], as well as the need for the protection practice of wild animal species (Young, 1998)[16].

The second stage started from 1930s to 1960s. During early 1930s, the concept of carrying capacity was initially applied in the tourism field (Manning, 1999)[17], though the subject of the studies was only extended from animals and environment to tourists and environment, and the concern was limited to the visible damage caused to animals and plants with different quantities of tourists. However, during this period, researches such as Meinecke's study of the impact of tourists on the tree roots in the California redwood parks (Meinecke, 1928)[18], Sumner's recommendations to the protection and management policies of California Mountains (Sumner, 1935)[19], as well as the regional planned capacity of bathing beaches in New York (1928)[20] might be regarded as the beginning of the study of tourism carrying capacity (McCool et al., 2001)[21].

The Second World War (1939-1945) stopped the progress of carrying capacity study. While in America, as large amounts of tourists came to the national parks after war in 1950s, the demanding for improving the crowded situation in the parks became increasingly fierce (Clawson, 1963)[22].

It was because since the economic concession in 1930s to 1950s, there was almost zero investment in the construction of facilities. The root cause was that many American managers for the leisure industry in early period were majored in forestry, wildlife zoology and range science who had never received professional training for park management. The tourists and the impact brought by them were soon defined as the (ecological) carrying capacity problem: the limitation of the initial design and management led to the fact that the facilities and resources failed to meet the gradually increasing demands of tourists (McCool et al., 2001)[23]. Devoto (1953)[24], Clawson (1959)[25] and many people wrote articles to express their dissatisfaction during the period.

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[12] Pearl, R., Reed, L. J. (1920). Ibid., p.17.
[13] Zhang Linbo, Li Wenhua, Liu Xiaofu, Wang Wei. (2009). Carrying Capacity: origin, development and prospective. *Acta Ecological Sinica*, 29(2), 878-888.
[14] Hadwen, S., Palmer, L. J. (1922). Reindeer in Alaska. *Bulletin of the U.S. Department of Agriculture*, No. 1089.
[15] Pearl, R. (1927). The growth of populations. *Quarterly Review of Biology*, 2(4), 532-548.
[16] Young, C. C. (1998). Defining the range: the development of carrying capacity in management practice. *Journal of History of Biology*, (31), 61-83.
[17] Manning, R. E. (1999). *Studies in Outdoor Recreation: Search and Research for Satisfaction.* Corvallis: Oregon State University Press.
[18] Meinecke, E. P. (1928). *The effect of excessive tourist travel on the California redwood parks.* California Department of Natural Resources, Division of Parks, Sacramento, 20.
[19] Sumner, E.L., Jr. (1935). A life history of the California quail, with recommendations for its conservation and management. *California Fish and Game,* 21, 167-256, 275-342.
[20] Committee on the Regional Plan of New York and its Environs. (1928). *Regional Survey of New York and its Environs. Vol.V, Public Recreation.* New York: Regional Plan of New York and its Environs, 116.
[21] McCool, S. F., Lime, D. W. (2001). Tourism carrying capacity: Tempting fantasy or useful reality? *Journal of Sustainable Tourism,* 9(5), 372-388.
[22] Clawson, M. (1963). *Land and Water for Recreation – Opportunities, Problems and Policies.* Chicago: Rand McNally and Company.
[23] McCool, S. F., Lime, D. W. (2001). Ibid., p.18.
[24] Devoto, Bernard. (1953). Let's close the national parks. *Harpers Magazine*, 207(1241), 49-52.
[25] Clawson, M. (1959). The crisis in outdoor recreation. *American Forests*, 65(3), 22-31, 40-41.

Based on the situation of the day, U.S. National Park Service proposed a ten-year's project at its fifty years' anniversary in 1956 which included 66 tasks to upgrade the park facilities. For the same reason, US Forest Service put forward a similar project named "Operation Outdoors" in 1957 and planned to fulfill it before 1962.

However, the actual tourists surpassed the conservative estimation of both projects. The number of tourists to forest park in 1959 was 15 million more than the estimated 66 million for 1962. A series of questions were reflected, such as "how many lands would be enough?", "what's the carrying capacity of the wild lands (forecast lands)?" and "is it necessary to manage the outdoor recreation activities from the perspective of sustainable development?" and so on (Wagar, 1964)[26].

At that time, the American parks had taken certain measures to manage the resting space. For example, in 1957 U.S. Forest Service set the rule that the distance between the camping tents of different families should be 100 inches. Besides, there could only be three campsites within one acre in order to accommodate the roads and toilets (United States Forest Service, 1957)[27]. US National Park Service allowed four to seven campsites within one acre (United States National Park Service, 1960)[28].

Japan witnessed the start-up of the study of tourism carrying capacity during this period which mostly examined the capacity for the tangible and limited spaces, falling far behind America.

The studies mainly included: Suzuki (1954)[29] stated in *Bathing Beach Plan* that the carrying capacity for the grassland beside the lake or swimming pool was 8m^2 (or 2.4 Tsubo) per person; Tamura (1948)[30] believed that the carrying capacity of seaside is 14 m^2 (or 4.2 Tsubo) per person; Shiota (1954)[31] thought that the square for long-term camping should be 500 m^2, and the wooden tent for eight persons should be 180 m^2, and it should be 56 m^2 for four persons; Eyama combined the study of Wagner towards the required green area in parks for Berlin citizens (Wagner Martin, 1915)[32], the New York local planning, the utilization situation in Japanese parks as well as the studies of previous scholars, and finally considered that the carrying capacity should vary according to the subject itself (ski resort, sea beach, natural park etc.) and the utilization modes (Eyama, 1956)[33].

The third stage started from 1960s to 1980s. Since the beginning of 1960s, the rudiment of the tourism carrying capacity theory has already taken shape as Wagar defined recreational carrying capacity and pointed out research questions in the article "*The carrying capacity of wild lands for recreation*" in 1964 (Wagar, 1964)[34].

[26] Wagar, J. A. (1964). The carrying capacity of wild lands for recreation. *Forest Science Monographs*, 7, 1-23.
[27] United States Forest Service. (1957). *Operation outdoors: Part 1: national forest recreation*. Washington, D.C.: U.S. Government Printing Office, 14.
[28] United States National Park Service. (1960). *National Park Service camping policy*. Washington, D.C.: NPS, 11.
[29] 鈴木忠義. (1954). 海水浴場の計画と施設. 国立公園, 5, 20-37.
[30] 田村剛. (1948). 国立公園講話. 明治書院, 163.
[31] 塩田敏志. (1954). 野営場の計画と施設. 国立公園, 1-3.
[32] Wagner Martin. (1915). *Städtische Freiflächenpolitik: Grundsätze und Richtlinien für Größe und Verteilung der verschiedenen Arten von sanitärem Grün im Stadtplane mit besonderer Berücksichtigung von Groß-Berlin*. Berlin: Heymann, 23-55.
[33] 江山正美. (1956). 自然公園収容力の基本問題. 造園雑誌, 19(3), 1-4.
[34] Wagar, J. A. (1964). Ibid., p.17.

In the field of ecology, the studies of Wagar (1964), Frissel & Duncan (1965)[35], Merriam & Smith (1974)[36] revealed that the utilization (of tourists) and the impact on the plants and soil presented a non-leaner relationship, showing that mild utilization would exert strong impact. Combining the studies of Godfrey & Godfrey (1981)[37], Hammitt & Cole (1987)[38], Leung & Marion (2000)[39] and so on in recent years, McCool & Lime (2001)[40] described the relation as:

(1) The impact would appear with the existence of tourists (consequently, only when there was no tourists would the negative impact disappear);

(2) For the areas with high frequency of visit, to decrease the utilization (of environment) sharply was a must to reduce the existing impact;

(3) If the impact was already very serious, then it would be too difficult to improve and it would last a long term.

The principle problems for the studies in ecological field during this period were (Stankey, 1980)[41]:

(1) Few long-term follow-up study (Speight, 1973)[42]. The only exception was an investigation conducted in Boundary Waters Canoe Area which lasted for five years (McCool et al., 1969; Merriam, 1974; Merriam et al., 1973)[43]. The main subject was the impact of tourists on the newly developed campsites, and it discovered that most of the campsites had suffered the most serious impact during the first two years.

(2) Not enough study about the impact of resting activities on waters. Only Merriam & Smith (1974)[44] studied the Escherichia coli, phosphate and opacity of the waters around the campsites. The result showed that the indicators for the regions near the campsites had a higher value while the other factors such as temperature and dissolved oxygen quantity were not impacted. As a result, they concluded that the resting activities had small impact on the quality of water.

[35] Frissel, S. S., Duncan, D. P. (1965). Campsite preference and deterioration. *Journal of Forestry*, 63(4), 256-260.
[36] Merriam, L. C. Jr., Smith C. K. (1974). Visitor impact on newly developed campsites in the Boundary Waters Cabie Area. *Journal of Forestry*, 72(10), 627-630.
[37] Godfrey, P.J., Godfrey, M.M. (1981). Ecological effects of off-road vehicles on Cape Cod. *Oceanus,* 23, 56-67.
[38] Hammitt, W.E., Cole, D.N. (1987). *Wildland Recreation: Ecology and Management*. New York: Wiley.
[39] Leung, Y. and Marion, J.L. (2000). Recreation impact and management in wilderness: A state-of-knowledge review. In Cole, D.N., McCool, S. F., Borrie, W.T. and O'Loughlin, J. (comps.) *Wilderness Science in a Time of Change*: Vol.5. *Wilderness Ecosystem, Threats, and management.* Proceedings RMRS-P-15-VOL-5. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Ogden, Utah, 23-48.
[40] McCool, S. F., Lime, D. W. (2001). Ibid., p.18.
[41] Stankey, G. H. (1980). Wilderness carrying capacity: management and research progress in the United States. *Landscape Research*, 5(3), 6-11.
[42] Speight, M. C. D. (1973). *Outdoor recreation and its ecological effects: a bibliography and review*. Discussion papers in conservation 4, University College, London, U.K., 35.
[43] McCool, S. F., Merriam, L. C., Jr. and Cushwa, C. T. (1969). *The condition of wilderness campsites in the Boundary Waters Canoe Area Minn*. Forest Research Notes 202, University of Minnesota, Miinneapolis, 4.
   Merriam, L. C., Jr., Smith C. K. (1974). Ibid., p.19.
   Merriam, L. C., Jr., Smith C. K., Milner,D.E., Chingtiao Huang, Tappeiner, J.C., Tappeiner II, Goeckermann Kent, Bioemendal, J.A. and Costello, T.M. (1973). *Newly developed campsites in the Boundary Waters Canoe Area: a study of 5 years' use.* St. Paul: Agricultural Experiment Station, University of Minnesota, 27.
[44] Merriam, L. C., Jr., Smith C. K. (1974), Ibid., p.19.

(3) Too less attention on the public health. For example, the study of Taylor & Erman (1979) [45] indicated that recreational utilization was beneficial to the growth of submerged plants. They believed that in the areas of mountains and rivers, human utilization would induce the nutrient to be accumulated at the bottom of the lakes, therefore enhancing the growth of submerged plants. However, though their investigation showed that in certain areas recreational activity would benefit the growth of plants, it was shortsighted from the perspective of public health.

(4) Too few studies on the impact of tourists on wild animals (quantity, distribution and behaviors of species etc). Only Speight (1973) [46], Stankey & Lime (1973) [47] and Ream (1980) [48] made some researches. The impact of tourists on the quantity of wild animals was very obvious, especially for the habitats. If the habitats were small or the quantity was limited, which became a tourist attraction, then the animals lived there would be easy to be disturbed by tourists. However, the studies relevant with this topic were seldom.

Actually, the physical-ecological impact (of tourists on recreational area) was a very complicated process, and sometimes it was even impossible to find out. At most times, for example, if the human activity at the campsite has caused damage to one of the species, some other specie with stronger vitality would appear to replace it and finally reach a new ecological balance (Verburg, 1974) [49].

During this period when tourism carrying capacity was being dug deeper in ecological field, it was also extended to the sociology field, triggering reflection on its social attribute. "Reflection on the impact of the utilization (of tourists) is not only limited to the 'physico-ecological' change to the environment, but also the impact on tourist experience" (Stankey, 1980) [50].

Though the study of Wagar (1964) [51] didn't mention the sociological impact of (tourists') "utilization" directly, it was involved in many points of the study. For example, it discussed the relationship between "congestion and recreational quality", and studied the relation of the number of tourists and the recreational quality under various utilization modes, each of which was stated in detail. The paper also mentioned the field research in McKinley National Park in the summer of 1958 which mainly examined the distances among the campers in the park and got the result that the distance varied according to the personality (taste) of the camper. More or less these belong to the research scope of tourism social carrying capacity.

Some scholars also studied the willingness of encounter during recreational activity. Lucas's (1964) [52] study in BWCA (Boundary waters Canoe Area) showed that people

[45] Taylor, T. P., Erman, D. C. (1979). The response of benthic plants to past levels of human use in high mountain lakes in Kings Canyon National Park, California, USA. *Journal of Environmental Management*, 9(3), 271-278.

[46] Speight, M. C. D. (1973). Ibid., p.20.

[47] Stankey, G., Lime, D. (1973). *Recreational carrying capacity: an annotated bibliography*. USDA Forest Service, General Technical Report, INT-3, 45.

[48] Ream, C. H. (1980). *Impacts of backcountry recreationists on wildlife: an annotated bibliography*. USDA Forest Service, General Technical Report, INT-81, 62.

[49] Verburg, K. (1974). *The carrying capacity of recreational lands: a review*. Occasional Paper No. 1, Prairie Region, Parks, Canada. 70.

[50] Stankey, G. H. (1980). Ibid., p.20.

[51] Wagar, J. A. (1964). Ibid., p.17.

[52] Lucas, R. C. (1964). *The recreational capacity of the Quetico-Superior area*. USDA Forest Service Research

who were canoeing expected less opportunity to encounter than people who were on a motorboat, and they were extremely reluctant to meet motorboat. Lime (1975)[53] testified the study of Lucas in the report released in 1975, indicating that three fourths of the people who went rafting claimed too many encounters (among each other) during one journey. And they believed that the quality of the journey would be impacted with over three times of encounter as it would lose the feeling to get close to nature. More than 90% of people who canoed claimed that they would not like to meet motorboat.

For the study of tourist perception tolerance, Stankey (1973)[54] found the general trend that the tolerance would decrease with the increase of utilization degree. It was discovered that 75% of the tourists would not like to meet backpackers during the journey and only 20% of them could accept four times of encounters. Fewer people showed their willingness or even acceptance of a party.

However, it didn't mean that the quality of outdoor experience would decrease with the increase of utilization degree. Stankey also discovered that compared to "no people", tourists tend to be more willing to meet other teams for one or two times. Pfister & Frenkel (1974)[55] found the similar situation during the investigation conducted towards the tourists in Rouge River that almost half of them preferred one time encounter compared to "no people". This could at least show that it was also important to provide proper opportunity to contact with other people.

Shebly (1980)[56] studied the relationship of actual contact and degree of satisfaction. After an investigation towards the drifters in Grand Canyon, it showed that though the river was frequently utilized, there was not so much actual contact among the drifters. It was quite relevant with the terrain, utilization mode and people's willingness to avoid contacting with others. One crucial problem was, even though the average actual contact rate surpassed the proper frequency agreed by the tourists (two or three times per day) as it reached zero to ten times per day, there seemed no relations between congestion and actual contact. The study finally believed that there was no direct negative correlation between the feeling of congestion and the overall satisfaction of the journey.

Other studies regarding the social attribute of carrying capacity were conducted during this period too, such as the behavior characteristics for experienced tourists who stayed overnight in campsite (Thomas et al., 1979)[57], the impact of large amounts of tourists on other tourists (Lime, 1972)[58] and the attitude of other tourists (Stankey, 1973)[59], the impact of tourists' illegal behavior and trace (waste) on other tourists as well as the satisfaction (Badger, 1975;[60] Lee, 1975[61]).

Paper LS-15, 34.

[53] Lime, D. W. (1975). Sources of congestion and visitor satisfaction in the Boundary Waters Canoe Area. *Proceedings of the Third Boundary Waters Canoe Area Institute*, Quetico-Superior Foundation, Duluth MN, 68-82.

[54] Stankey, G. H. (1973). *Visitor perception of wilderness recreation carrying capacity*. USDA Forest Service Research Paper, INT-142, 61.

[55] Pfister, R. E., Frenkel, R. E. (1974). *Field investigation of river use within the wild river area of the Rogue River*. Oregon: Interim Report to Oregon State Marine Board, 112.

[56] Shelby, Bo. (1980). Crowding models for backcountry recreation. *Land Economics*, 56(1), 1-27.

[57] Thomas, A. H., Peter, D. (1979). Systematic observation of use levels, campsite selection and visitor characteristics at a high mountain lake. *Journal of Leisure Research*, 11(4), 307-316.

[58] Lime, D. W. (1972). *Large groups in the Boundary Waters Canoe Area – Heir numbers, characteristics, and impact*. USDA Forest Service Research, Note NC-142, 4.

[59] Stankey, G. H. (1973). Ibid., p.21.

[60] Badger, T. J. (1975). *Rawah Wilderness crowding tolerances and some management techniques: an aspect of*

What's more, as the complexity of carrying capacity – "it is decided by the original construction intention of the facility and no carrying capacity is suitable for every area" – was gradually recognized, it triggered reflections on the questions of managerial targets that "the available utilization degree of (wild area)" (Lime, 1970)[62] and "what kind of changes (caused by tourist utilization) are acceptable?".

For example, based on the figures in 1971, Grand Canyon National Park in America allowed maximal 96, 500 people per day to drift on the Colorado River in the park in 1972. Later the figure was modified to 169, 500 according to the river management plan. However, the disputes existed on the questions such as what should be the correct figure and how to manage it. Since then, the parks and protection zones took different ways to consider the problems of carrying capacity and the restriction of maximal utilization in policy.

Meanwhile, with the increase of experience and knowledge in management and other aspects, the carrying capacity of facilities were also considered and interpreted to be the allowed overall maximal resting utilization based on regional management targets. It included two layers of meaning: (1) carrying capacity was not fixed or incoherent; (2) carrying capacity was diversified with different research purposes.

The Japanese academia has gradually extended the study of carrying capacity from the physical (body) level of tourists to the spiritual level, incorporating the spiritual (feeling) sense of distance into the study of carrying capacity.

However, no matter in quantity or the depth of study, it fell behind the leading countries such as America. The main studies in Japanese academia during this period were: Shinshi (1970)[63] studied the touring route and the distance among tourists in the park; Eyama (1974)[64] was entrusted by the Japan Environmental Agency to study the carrying capacity of natural park; Kondou and other scholars (1977)[65] studied the carrying capacity of the grassland in parks; Mima (1977)[66] made a research on the width of the hiking paths of Hakusan National Park.

It was easy to see that from 1960s to 1980s, the study of carrying capacity went deeper and more specific in the physico-ecological aspect. The research in ecological field showed that there was non-linear relationship between "utilization" and "impact". Meanwhile, the carrying capacity of (manmade) facilities was added to the research scope. What's more, the study of social carrying capacity started at this time.

The fourth stage started from 1980s to date. As the extension of carrying capacity,

social carrying capacity. Fort Collins: M.S. thesis, Colorado State University, 83.
[61] Lee, R. G. (1975). *The management of human components in the Yosemite National Park ecosystem: Final research report*. Yosemite Nat'l Park CA: The Yosemite Institute, 134.
[62] Lime, D. W. (1970). Research for the determining use capacities of the Boundary Waters Canoe Area. *Naturalist* 21(4), 9-13
[63] 進士五十八. (1970). 公園設計に関する基礎的研究(第一報)—特に一定空間内に於ける人間の占有位置及び占有空間規模の特性について. 造園雑誌, 33(3), 22-29.
[64] 江山正美, 他. (1974). 自然公園における収容力に関する研究(最終報告). 環境庁自然保護局, 107.
[65] 近藤三雄, 小沢知雄. (1977). 芝生地の収容力に関する基礎的研究(I). 造園雑誌, 40(3), 11-23.
    近藤三雄, 安藤茂子, 小沢知雄. (1979). 芝生地の収容力に関する基礎的研究(II). 造園雑誌, 43(2), 12-19.
[66] 美馬秀夫. (1977). 白山における許容登山利用へのアプローチ. 国立公園, 333, 1-3.

tourism carrying capacity was endowed with more connotations and the research scope was expanded to economic, political and managerial fields. Compared to before, the research methods were diversified and some case studies applied the existing theory into practice.

The theory of LAC (Limits of Acceptable Change) pointed out by Stankey (1984)[67] and others in 1984 marked that the perspective of tourism carrying capacity study was gradually changing to be more integral and systematic.

The LAC theory was based on following five acknowledges: (1) specific targets should be set up to confirm the protected content of many managerial actions; (2) there would always be some environmental changes in the system of nature; (3) any recreational utilization would lead to certain changes; (4) the question for management was the limits of acceptable changes; (5) it was necessary to examine the result of management so as to make sure if the actions were effective. The method was firstly applied to the wild animal management by USDA Forest Service.

Later, American National Park and Recreational Act required the National Park Service (NPS) to include the capacity management into the overall management plan of the park (Budruk, 2001)[68]. To this end, the researchers in the NPS systematically proposed VERP (Visitor Experience & Resource Protection) theory as the planning framework for the implementation of capacity policies as well as the tool for monitoring and management (National Park Service, 1997)[69].

Apart from LAC and VERP, many scholars studied tourism carrying capacity with models from different perspectives, marking that the theoretical study of tourism carrying capacity was becoming more and more systematic and specific. For example, there was VIM (Visitor Impact Management) (Graefe et al., 1990)[70], VAMP (Visitor Activities Management Process) (Nilsen et al., 1998)[71], ROS (Recreation Opportunity Spectrum) (Clark et al., 1979)[72], TOMM (Tourism Optimization Management Model) (Manidis, 1997)[73], PAVIM (Protected Areas Visitor Impact Management) (Farrell et al., 2002)[74] and so on. The research methods and main application area were shown in following table (Table 2-1.).

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[67] Stankey, G. H., McCool S. F., Stokes G. L. (1984). Limits of acceptable change: A new framework for managing the Bob Marshall Wilderness Complex. *Western Wildlands,* 10(3), 33-37.
[68] Budruk, M., Valliere, W., Manning, R., et al. (2001), Crossing Programmatic Boundaries: Integrative Approaches to Managing the Quality of the Visitor Experience. *The George Wright Forum*, 18(3), 124-131.
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[73] Manidis, R. C. (1997). *Developing a Tourism Optimization Management Model (TOMM), A Model to Monitor and Manage Tourism on Kangaroo Island, South Australia*. Surry Hills, New South Wales: Manidis Roberts Consultants.
[74] Farrell, T. A., Marion, J. L. (2002). The Protected Area Visitor Impact Management (PAVIM) Framework: A Simplified Process for Making Management Decisions. *Journal of Sustainable Tourism*, 10(1), 31-48.

Table 2-1. Different Research Methods and Main Application Areas of Tourism Carrying Capacity

Research methods	Main application area
LAC	National reserve
VERP	American National Park
VIM	Scenes in national reserve
ROS	Protected and multipurpose tourist area based on natural reserve
TOMM	Tourism community based on national landscape
VAMP	Canadian National Park, and other areas
PAVIM	Nation reserve

Source: Zhang Xiaoming. (2004). From Theoretical Framework to Practical Application: Progress in Tourism Environmental Capacity Research. *Resource Science*, 26(4), 78-88.

Case studies during this period made remarkable progress too. From the microscopic level of tourist areas, the main studies were: (1) of national parks and protection zones, such as Cifuentes (1990)[75]，Papageorgiou & Brotherton (1999)[76], Lawson (2003)[77], Nghi (2007)[78], Yuksek (2008)[79] and so on; (2) of tourist areas and sea beach, such as Sowman (1987)[80], Saveriades (2000)[81], Silva (2002)[82] and so on; (3) of tourist activities, such as Symmonds (2000)[83], Tarrant & English (1996)[84], Kopke (2008)[85], Diedrich (2009)[86], Sterl (2004)[87] and so on.

From the macroscopic level of countries, the main studies were: (1) Brown (1997)[88] made a research in Maldives and Nepal and pointed out that the tourism utilization had

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[75] Cifuentes, M., Alpizar, W., Barroso, F., Courrau, J., Falck, M. L., Jimenez, R., Ortiz, P., Rodriguez, J., Romero, J. C., Tejada, J. (1990). *Capacidad de CargaTuristica de la Reserva Biologica Carara*. Informe de Consulta, Servicio de Parques Nacionales/CATIE, Costa Rica.

[76] Papageorgiou, K., Brotherton, I. (1999). A Management Planning Framework Based on Ecological, Perceptual and Economic Carrying Capacity: The Case Study of Vikos-Aoos National Park, Greece. *Journal of Environmental Management,* 56, 271-284.

[77] Lawson, S. R., Manning, R. E., Valliere, W. A., Wang, B. (2003). Proactive Monitoring and Adaptive Management of Social Carrying Capacity in Arches National Park: an Application of Computer Simulation Modeling. *Journal of Environmental Management,* 68, 305-313.

[78] Nghi, T., Lan, N. T., Thai, N. D., Mai, D., Thanh, D. X. (2007). Tourism Carrying Capacity for PhongNha-Ke Bang and Dong Hoi, Quang Binh Province. *VNU Journal of Science, Earth Sciences,* 23, 80-87.

[79] Yuksek, T., Cengiz, T., Yuksek, F. (2008). Dogal Alanlarda Festival Etkinliklerinin Koruma-Kullanma Acysyndan Degerlendirilmesi: Kafkasor Kultur, Sanat ve Turizm Festivali Orneei. *Ekoloji*, 17(67), 37-45.

[80] Sowman, M. (1987). A Procedure for Assessing Recreational Carrying Capacity of Coastal Resort Areas. *Landscape and Urban Planning,* 14, 331-344.

[81] Saveriades, A. (2000). Establishing the Social Tourism Carrying Capacity for the Tourist Resorts of the East Coast of the Republic of Cyprus. *Tourism Management,* 21, 147-156.

[82] Silva, C. P. (2002). Beach Carrying Capacity Assessment: How Important is it? *Journal of Coastal Research,* 36, 190-197.
    Silva, C. P., Alves, F. L., Rocha, R. (2007). The Management of Beach Carrying Capacity: The Case of Northern Portugal. *Journal of Coastal Research,* 50, 135-139.

[83] Symmonds, M. C., Hammitt, W. E., Quisenberry, V. L. (2000). Managing Recreational Trail Environments for Mountain Bike User Preferences. *Environmental Management,* 25(5), 549-564.

[84] Tarrant, M. A., English, D. B. K. (1996). A Crowding-based Model of Social Carrying Capacity: Applications for Whitewater Boating Use. *Journal of Leisure Research,* 28 (3), 155-168.

[85] Kopke, K., O'Mahony, C., Cummins, V., Gault, J. (2008). *Assessment of Coastal Recreational Activity and Capacity for Increased Boating in Cork Harbour*. Coastal and Marine Resources Centre Report, University College Cork, Cork.

[86] Diedrich, A., Balaguer, P., Tintore, J. (2009). *Shifting the Carrying Capacity Concept from Theory into Practical Application: An Example Using Recreational Boats in Mallorca, Balearic Islands, Spain*. In: Albers, A., Myles, P. B. (eds), Proceedings of CMT 2009, 6th International Congress on Coastal and Marine Tourism, Nelson Mandela Bay, 264-267.

[87] Sterl, P., Wagner, S., Arnberger, A. (2004). *Social Carrying Capacity of Canoists in Austria's Danube Floodplains National Park*. Working Papers of the Finnish Forest Research Institute, 256-263.

[88] Brown, K., Turner, H. K. et al. (1997). Environmental carrying capacity and tourism development in the Maldives and Nepal. *Environmental Conservation,* 24, 316-325.

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exceeded the ecological capacity; (2) Saveriades (2000)[89] studied the tourism carrying capacity of the Republic of Cyprus based on an investigation on the perception of local residents; (3) De Ruyck (1997)[90] studied the condition of the beaches in South Africa from the perspective of social carrying capacity.

Though the studies of tourism carrying capacity had extended to the economic, political, social and cultural, and management fields, in-depth studies were rare because most researchers were only aware of its impact on tourism carrying capacity and point out corresponding impact or factors for examination (Coccossis & Mexa, 2004;[91] Sayan & Atik, 2011;[92] Manning & Lime, 2000;[93] Castellani et al., 2007;[94] Farrell & Marion, 2002;[95] O'Reilly, 1986[96]), few studies had put it into practice.

On one hand, it was because the designed indicators to examine in these fields were more difficult compared to physical level (ecology, facility) and low spiritual level (society). It was impossible to examine the economic, political, social and cultural, management fields in a quantitative way due to the uncertainty of future and the subjectivity of indicators.

On the other side, there were many factors influencing the tourism carry capacity of tourist areas, some belonging to its own attribute and some depending on the tourist utilization. Besides, even for the same tourist area, the carrying capacity would be different at different times due to the fact that its own attributes or the utilization (of tourists) would subject to the changes of time (or season).

During the period, the Japanese tourism academia still focused the study on facility – ecology and social carrying capacity, almost no relevant with the other aspects of tourism carrying capacity.

Most of the existing studies were empirical studies, and there was no study of carrying capacity from the systemic perspective. The studies on facility – ecology aspect were: Maenaka and Yoshida (1989)[97] studied the carrying capacity of footpath from the perspective of the velocity of walkers; Aikou (1993, 1994, 2003)[98] studied the carrying capacity of the ski resort in Daisetsuzan National Park from the point of view

[89] Saveriades, A. (2000). Ibid., p. 25.
[90] De Ruyck, M. C., Soares, A. G. et al. (1997). Social carrying capacity as a management tool for sandy beaches. *Journal of Coastal Research,* 13(3), 822-830.
[91] Harry Coccossis, Alexandra Mexa. (2004). *The challenge of tourism carrying capacity assessment: theory and practice*. Ashgate Publishing, Ltd., 293.
[92] Sanyan, M. S., Atik, M. (2011). Recreation Carrying Capacity Estimates for Protected Areas: A Study of Termessos National Park. *Ekoloji,* 20(78), 66-74
[93] Manning, R. E., Lime, D. W. (2000). *Defining and Managing the Quality of Wilderness Recreation Experiences*. USDA Forest Service Proceedings RMRS-P-15-VOL-4.
[94] Castellani, V., Sala, S., Pitea, D. (2007). A new method for tourism carrying capacity assessment. *Ecosystems and Sustainable Development VI, WIT Transactions on Ecology and the Environment,* 106, 365-374.
[95] Farrell, T.A. & Marion, J. L. (2002). Ibid., p.24.
[96] O'Reilly, A. M. (1986). Tourism carrying capacity: Concepts and issues. *Tourism Management,* 7(4), 254 - 258.
[97] 前中久行, 吉田成志. (1989). 歩行速度から見た歩道の収容力について. 造園雑誌, 52(5), 187-191.
[98] 愛甲哲也, 小林昭裕. (1993). 大雪山国立公園における登山利用者からみたキャンプ場の混雑感評価と関わる要因. 造園雑誌, 56(5), 169-174.
　愛甲哲也, 浅川昭一郎, 小林昭裕. (1994). 大雪山国立公園におけるキャンプ場の利用人数と混雑感評価について. 造園雑誌, 57(5), 319-324.
　愛甲哲也. (2003). 山岳性自然公園における利用者の混雑感評価と収容力に関する研究. 北海道大学大学院農学研究科邦文紀要, 25(1), 1-114.

of congestion. Shinshi (1986)[99] studied the position and area occupied by tourists in the parks; Aoki (1986, 1990)[100] studied the congestion of tourists in parks.

Studies on social aspect mainly include: Mizoguchi (1985)[101] studied the sense of congestion for the tourists; Kobayashi (1996)[102] studied the tourists' consciousness to tour around the park.

The Chinese tourism academia started to study the tourism carrying capacity in the middle of 1980s. With a late start, the development was rapid and the research perspectives were soon in line with leading countries like America. The studies of tourism carrying capacity were focusing on systematic and integral perspectives. The weakness lied in the shortage of empirical studies to enrich the theory which was in accordance with Chinese characteristic.

The studies of tourism carrying capacity from the systematic and integral perspectives are: Tan Wenken (2008)[103] constructed the basic model of city comprehensive carrying capacity based on Verhulst-Peadlogiistic equation; Wang Yuming (2007)[104] studied the urban tourism capacity with Shanghai as the subject; Yuan Jiyu (2006)[105] discussed the composition of tourism environmental carrying capacity system and the construction of indicator system; Li Tianyuan (2001)[106] believed that the traditional tourism carrying capacity studies focused on the limitation of tourists reception which had limited the application of carrying capacity theory in practice and further pointed out suggestions for the implementation of growth management strategy in practice; Bao Jigang (1999)[107] proposed five basic capacities (tourism psychological capacity, tourism resource capacity, tourism ecological capacity, tourism economic capacity and tourism social capacity) constituting the concept mechanism of tourism environmental carrying capacity with the Summer Palace as the subject; Cui Fengjun (2001)[108], Shu Jing (2001)[109] held the similar opinions with Bao Jigang; Hu Bingqing (1995)[110] put forward the limiting factors of tourism environmental carrying capacity and the law of minimum, and based on this he came up with the mathematical model of tourism environmental carrying capacity; Liu Yaping

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[99] 進士五十八. (1986). 公園設計に関する基礎的研究(第Ⅰ報)特に一定空間内に於ける人間の占有位置及び占有空間規模の特性について. 造園雑誌, 33(3), 22-29.
[100] 青木陽二. (1986). 同時在園者数による混雑感の分析. 造園雑誌, 50(5), 108-111.
　青木陽二, 奥田直久. (1990). 上高地における被験者による自然風景地の物理的環境評価の試み. 環境科学会誌, 3(4), 293-300.
[101] 溝口周道, 長岡正樹. (1985). 自然風景地における利用者意識について―特に混雑感に関連し考察. 日本造園学会関東支部大会研究発表・報告要旨, 3, 17-18.
[102] 小林昭裕. (1996). 山岳性自然公園における利用者の意識構造に関する研究. 北海道大学学位論文, 150.
[103] Tan Wenken, Shi Yishao, Sun Li. (2008). Some theoretical issues on urban carrying capacity. *China Population Resources and Environment*, 18(1), 40-44.
[104] Wang Yuming. (2007). Study on the metropolis tourism capacity & bearing based on the case of Shanghai. *China Population Resources and Environment*, 17(5), 43-50.
[105] Yuan Jiyu, Yu Jing, Yuan Hao. (2006). Study on the carrying capacity of the city tourism environment. *Industrial Technology & Economy*, 25(7), 130,134.
[106] Li Tianyuan. (2001). Views on the application of tourism carrying capacity theory. *Nankai Business Review*, 4(3), 57-60.
[107] Bao Jigang, Chu Yifang. (1999). *Tourism geography*. Beijing: Higher Education Press, 143-166.
[108] Cui Fengjun. (2001). *The Protection and management of scenic spots*. Beijing: China Travel & Tourism Press.
[109] Shu Jing. (2001). The concept and measuring of tourism carrying capacity. *Journal of Beijing Second Foreign Language College*, (3), 14-19.
[110] Hu Bingqing. (1995). Calculation of Tourist Environment Capacity. *Research of Environmental Sciences*, 8(3), 20-24.

$(2011)^{111}$ took Guangxi Bama Panyang River as an example and defined the meaning of tourism carrying capacity and relevant indicators, as well as calculated the local carrying capacity; Yan Boya and Bi Chao $(2011)^{112}$ calculated and evaluated the tourism environmental carrying capacity of Xi'an.

The studies of tourism carrying capacity from the perspective of ecology (including manmade facilities) were: Zhao Honghong $(1983)^{113}$ studied the environmental carrying capacity of Suzhou gardens; Song Lifu $(1985)^{114}$ studied the impact of tourism on environmental changes in Beijing and Tianjin areas; Wang Jiaxi $(1986)^{115}$ studied the current environmental status of Suzhou classic gardens from three aspects of atmospheric pollution, water pollution and noise pollution; Wang Zirong $(1988)^{116}$ conducted systematic examination of the water, atmosphere and plant environment quality in Zhangjiajie National Forest Park; Zhang Weiguo $(2004)^{117}$ worked on the predictive studies of the tourism capacity in circuit scenic spots from the perspective of environmental carrying capacity.

The studies of tourism carrying capacity from the perspective of sociology were: Li Zhen $(1998)^{118}$ applied the indicators such as sensitive level, landscape importance value and tourist impact index to the study of the impact of tourism on the vegetations of Mount Danxia; Hu Xijun $(2005)^{119}$ studied the tourism social carrying capacity of Jinhua; Lu Xiaoli $(2005)^{120}$ studied the calculation and management of the tourism social carrying capacity; Wen Shouwen $(2008)^{121}$ made a comparative study of the tourism social carrying capacity in developed areas and developing areas; Xiao Lai $(2011)^{122}$ took Yiwu City as an example to discuss the urban tourism social carrying capacity; Yao Li $(2011)^{123}$ applied LAC theory to study the ecological and physiological carrying capacity of Zhejiang Tianmu Mountain Nation Reserve; Liang Chunxiang $(2009)^{124}$ studied the traveling population development among China, Japan and Korea from the perspective of social demography.

The studies of tourism carrying capacity from the economic perspective were: Wang

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[111] Liu Yaping, Liao Ziling. (2011). An empirical study of tourist bearing capacity and TBCI assessment. *Journal of Guuangxi University (Philosophy and Social Science)*, 33(2), 44-50.

[112] Yan Boya, Bi Chao. (2011). Calculation and evaluation of the tourism environmental carrying capacity of Xi'an. *Journal of Northwest University (Natural Science Edition)*, 41(4), 719-722.

[113] 赵红红. (1983). 苏州旅游环境容量问题初探. 城市规划, 3, 46-53.

[114] Song Lifu, Yang Guanxiong, Guo Laixi. (1985). Development of Beijing and Tianjin area for a tourist environment. *Acta Science Circumstance*, 5(3), 255-265.

[115] Wang Jiaxi. (1986). Study on the value of tourism of Suzhou Garden and environment protective strategy. *Journal of Environment Science*, 7(4), 83-88.

[116] Wang Zirong, Hao Xiaobo. (1988). The study on the variation of environmental quality and its countermeasures in Zhang jiajie National Forest Park. *China Environmental Science*, 8(4), 23- 30.

[117] Zhang Weiguo. (2004). *Study on the capacity prediction of the tourism space in circuit scenic spot [D]*. Zhejiang University.

[118] Li Zhen, Bao Jigang, Qin Chaofeng. (1998).The Impact of Tourist Development on the Vegetation Cover of Mount DanXia, Guangdong. *Acta Geographica Sinica*, 53(6), 554-561.

[119] Hu Xijun, Zhu Lidong, Ma Yongjun, Ye Wei. (2005). Study on the tourism social capacity in Jinhua. *Economic Geography*, 25(4), 590-592.

[120] Lu Xiao li, Wu Chunyou, Yu Haifeng. (2005). Study on measurement of tourism sociological carrying capacity. *Nankai Business Review*, 8(1), 75-78.

[121] Wen Shouwen. (2008). Comparison of social bearing capacity for tourism between developed and underdeveloped regions. *Economic Geography*, 28(5), 887-890.

[122] Xiao Lai. (2011). Study on social capacity of city tourism for Yiwu City. *Business Economy*, (21), 41-42.

[123] Yao Li. (2011). *Study on psychology environmental bearing capacity of Eco-tourism in Zhejiang Tianmu mountain national nature reserve based on LAC theory [D]*. Beijing Forestry University.

[124] 梁春香. (2009). 中日韩跨国旅行人口发展研究. 吉林大学博士学位论文.

Hui (2006)[125] established the evaluation model of urban environmental carrying capacity based on the economic theory of profit maximization and the relation between marginal revenue and marginal cost; Cui Fengjun (1997)[126] put forward the concept of tourism income value when assessing the tourism bearing capacity index of Mount Taishan; the article *Yunnan Stone Forest Applying for Natural Legacy of World (2002)*[127] defined the concept of "tourism economic carrying capacity" and studied the local tourism economic carrying capacity; Zhang Wu and Chen Xuejun (2007)[128] defined tourism economic carrying capacity in *Tourism Resources* and came up with the mathematical formula; Other scholars such as Deng Aimin[129], Tao Li[130], Yang Jun[131], Wang Kunxin (2003)[132] and Yan Zhiwu (2003)[133] studied the tourism carrying capacity and proposed mathematical formulas from the economic perspective.

Due to its unique national characteristics and regional features, there were abundant studies of tourism carrying capacity from the perspectives of politics and event tourism, focusing on the topics including Cross-straits relation, China, Japan and South Korea relation, mega-events such as SARS, Red Tourism and so forth.

The main studies were: Sun Gennian (2009), Wang Jiejie and Shu Jingjing (2009, 2010, 2011)[134] studied the impact of critical incidents on tourists; Liu Jun (2011)[135] analyzed the perception and attitude of Hainan residents towards the policy of international tourism island; Zeng Benxiang (2005)[136] took SARS incident as an example and studied the impact of short-term events on tourism; Xue Jia (2010)[137] studied in the paper the impact of mega-events on tourism passenger flow from Japan to China; Piao Song'ai and Zhang Xiaoni (2008)[138] studied the progress and influencing factors of international tourism among China, Japan and Korea against the background of national politics and mega-events; Liu Guanglei and He Yushan (2011)[139] studied the political function of tourism from the perspective of grass-root government; Bian

[125] Wang Hui, Lin Jianguo, Zhou Jiaming. (2006). Urban tourism carrying capacity model establishment and analysis [J]. *Journal of Dalian Maritime University*, 32(3), 18-20, 25.
[126] Cui Fengjun, Yang Yongshen. (1997). A study on the time space distribution features and utility intensity of the TEBC Resource of Mt. Tai. *Geographical Research*, 16(4), 47-55.
[127] 云南石林申报世界自然遗产研究组著. (2002). 云南石林申报世界遗产研究. 科学出版社, 201-202.
[128] Zhang Wu, Chen Xuejun. (2007). *LvYou ZiYuanXue*. Harbin: Harbin Cartographic Publishing House, 176-177, 309.
[129] 邓爱民, 刘代泉. (2000). 旅游资源开发与规划. 旅游教育出版社, 176-177.
[130] Tao Li. (2007). *Tourism Geography*. Science Press, 258-259.
[131] 杨军. (2008). 旅游公共管理. 南开大学出版社, 112-114.
[132] 王昆欣. (2003). 旅游景区管理. 东北财经大学出版社, 27.
[133] 鄢志武. (2003). 旅游资源学. 武汉大学出版社, 111-112.
[134] Wang Jiejie, Sun Gennian, Shu Jingjing. (2009). The Impact of Sino-American Relations and Crisis Events on the Interactive Tourism Flows in the Past Twenty Years. *Tourism Tribune*. 5(5), 12-19.
　　Sun Gennian, Wang Jiejie. (2009). The Impact of Cross-Strait Relation Changes on the Inbound Tourists of Mainland China from Taiwan in the Past 20 Years. *Acta Geographica Sinica*, 64(12), 1513-1522.
　　王洁洁. (2011). 国际关系及重大事件对出入境旅游的影响. 陕西师范大学博士论文.
　　Wang Jiejie, Sun Gennian. (2010). The Impact of Mainland-HK Relations and Important Events on Interactive Tourism Flows in Recent 20 Years. *Economic Geography*, 2, 317-323
[135] Liu Jun. (2011). Hainan Residents' Perception and Attitude Towards the Policy Impact of International Tourism Island. *Tourism Tribune,* 6(26), 21-28.
[136] Zeng Benxiang, Carter, R. W., Delacy, T. (2005). The impact of short-term crisis on tourism: SARS epidemic in China. *Journal of Guilin Institute of Tourism*, 16(2), 30-39.
[137] 薛佳. (2010). 社会环境下日本游客入境旅游及格局地域变化分析. 山西师范大学硕士论文.
[138] Piao Songai, Zhang Xiaoni. (2008). Development Process and Influencing Factors of International Tourism in China, Japan and Korea. *Journal of Dalian Maritime University (Social Science Edition)*, 7, 95-99.
[139] 刘广磊, 何玉姗. (2011). 浅析乡镇政府旅游政治功能的发挥. 经济视角, 2, 113-114.

Xianhong (2011)[140] studied the impact of relevant events between China and Korea on mutual tourism flow; Wang Jiejie (2010)[141] studied the antisymmetry between US Taiwan policy and interaction of tourism; Yang Anhua and Liang Hongzhi (2008)[142] studied the political dimension of tourism; Tang Zhiming (2006)[143] analyzed the politics of tourism from the perspective of politics; Yang Jing (2001)[144] studied the ideological and political education in Red Tourism; Yuan Shuqi (2003)[145] explored the tourism development topic for the event of establishing direct flights between Fujian and Taiwan.

2.2 Summary

From the literature review above and the interdisciplinary development view of CC theory, related theories of UTCC study are mainly focus on the following 5 areas:

Demographic field is one of the earliest disciplines for the carrying capacity research of population problems. Thomas (1798)[146], Pearl & Reed (1920)[147] are representatives to study the population problem of growth limitation from the limited resources perspective and raise mathematical model of population growth which is the initial prototype of CC model.

The ecology field for the research of the carrying capacity can be divided into two parts: before the ecological research is combined with the tourism, it mainly focuses the applied ecology study, including farm maximum carrying capacity research (Hadwen & Palmer, 1922)[148], the growth model in the limits of demographic field in fitting verification of ecology (Pearl, 1927)[149].

After the research is combined with tourism, the research object extends from the relationship between animal and environment to tourists and environment. The research focus also develops from the initial concern on the visible damage to animal and plant by tourists (Meinecke, 1928;[150] Sumner, 1935[151]) to the tourist carrying capacity of the resource or facility (Wagar, 1964;[152] Frissel & Duncan, 1965;[153] Merriam & Smith, 1974;[154] Suzuki, 1954;[155] Tamura, 1948;[156] Shiota, 1953;[157]

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[140] 卞显红, 金霞, 秦萍, 安锺洙. (2011). 中韩相关事件对双向旅游流流动的影响. 商业研究, 187-192.
[141] Wang Jiejie, Sun Gennian, Zheng Peng, Ma Lijun. (2010). The Duality of USA's Taiwan Policy and the Asymmetry of Tourism Interaction. *Thinking*, 36(3), 117-121.
[142] Yang Anhua, Liang Hongzhi. (2008). On Politics Dimension of Tourism Research. *Tourism Tribune,* 23, 81-85.
[143] Tang Zhiming. (2006). On the Politics Analysis of Politics of Tourism. *Tourism Tribune,* 21, 83-89.
[144] Yang Jing. (2001). *The research of ideological and political education in Red Travel* [D]. University of South China.
[145] 袁书琪, 李爽, 余美珠, 韩卢敏. (2003). 闽台直航往来通航事件旅游开发探讨. 中国地理学会 2003 年学术年会文集.
[146] Thomas M. (1978). Ibid., p. 17.
[147] Pearl, R., Reed, L. J. (1920). Ibid., p. 17.
[148] Hadwen, S., Palmer, L. J. (1922). Ibid., p. 18.
[149] Pearl, R. (1927). Ibid., p. 18.
[150] Meinecke, E. P. (1928). Ibid., p. 18.
[151] Sumner, E.L., Jr. (1935). Ibid., p. 18.
[152] Wagar, J. A. (1964). Ibid., p. 17.
[153] Frissel, S. S., Duncan, D. P. (1965). Ibid., p. 20.
[154] Merriam, L. C. Jr., Smith C. K. (1974). Ibid., p. 20.
[155] 鈴木忠義. (1954). Ibid., p. 19.
[156] 田村剛. (1948). Ibid., p. 19.
[157] 塩田敏志. (1954). Ibid., p. 19.

Eyama, 1965[158]).

Two research perspectives are brought out: one is to study the maximum value of the living creatures in a certain circumstance and a certain period of time (Hadwen & Palmer, 1922)[159] from the perspective of the living creature number. The other one is to study the maximum utilization by the living creatures in a certain circumstance and a certain period of time (Stankey, 1984)[160] from the perspective of the resource itself.

The two representations show two different research perspectives, the former focused on the maximum number of the living creature in a certain circumstance, while the latter concerns the maximum utilization of the circumstance. But from a modern perspective, whether for the former or the latter, the main object of carrying capacity study is to maintain a harmonious coexistence relationship between living creatures and the circumstance.

Sociological research is done mainly from two perspectives: groups and individuals. The group perspective focuses on the relation of tourist population scale and the quality of the tourist recreation perception (Wagar, 1964;[161] Stankey, 1973[162]). Individual perspective includes the encounter willingness of individual tourists (Lucas, 1964;[163] Lime, 1972[164]), behavior characters of individual tourists (Heberlein & Dunwiddle, 1979)[165], influence with each other of individual tourists (Badger, 1975;[166] Lee, 1975[167]), psychological perception research of individual tourists (Stankey, 1973;[168] Shebly, 1980;[169] Aoki, 1986[170]), space perception of individual tourists (Shinshi, 1970;[171] Aiko, 2003[172]) and so on.

Economic research is done mainly from the theory and the practice. From the theory, the study covers the scarcity principle of UTCC in economic field (Kahn, 1976)[173], game theory on the priority of environmental protection and tourism economic development for tourists and residents (Pearce & Turner, 1990;[174] Kallis & Coccossis, 2004[175]), the sustainable development, and the assessment of UTCC application based on economic theories (Wang Hui et al.，2006)[176]. From the practice, the study covers

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[158] 江山正美. (1956). Ibid., p. 19.
[159] Hadwen, S., Palmer, L. J. (1922). Ibid., p. 18.
[160] Stankey, G. H., McCool S. F., Stokes G. L. (1984). Ibid., p. 23.
[161] Wagar, J. A. (1964). Ibid., p. 17.
[162] Stankey, G., Lime, D. (1973). Ibid., p. 21.
[163] Lucas, R. C. (1964). Ibid., p. 21.
[164] Lime, D. W. (1972). Ibid., p. 22.
[165] Heberlein, T. A., Dunwiddle P. (1979). Systematic observation of use levels, campsite selection and visitor characteristics at a high mountain lake. *Journal of Leisure Research*, 11(4), 307-316.
[166] Badger, T. J. (1975). Ibid., p. 22.
[167] Lee, R. G. (1975). Ibid., p. 22.
[168] Stankey, G., Lime, D. (1973). Ibid., p. 21.
[169] Shelby, Bo. (1980). Ibid., p. 22.
[170] 青木陽二. (1986). Ibid., p. 27.
[171] 進士五十八. (1970). Ibid., p. 23.
[172] 愛甲哲也. (2003). Ibid., p. 26.
[173] Kahn, H., Brown, H., Martel, L. (1976). *The Next 200 Years: a Scenario for America and the World.* William Morrow, New York. 162-186.
[174] Pearce, D. W. and Turner, R.K. (1990). *Economics of Natural Resources and the Environment.* The Johns Hopkins University Press. 392.
[175] Kallis, G. and H. Coccossis. (2004). *Theoretical reflections on limits, efficiency and sustainability: implications for tourism carrying capacity assessment.* The Challenge of Tourism Carrying Capacity Assessment: Theory and Practice, 15-36.
[176] Wang Hui, Lin Jianguo, Zhou Jiaming. (2006). Ibid., p. 28.

the research of the pricing system of the scenic spots (Kuo, 2002)[177], the tax system of the tourism (Ajuntament de Calvia Mallora, 1999)[178], cost system research (pollution/use/consumption) (Borg, 1993)[179], balance of payments system research (Wang, 1996)[180] and so on.

Studies from political perspective are mainly proposed by Hall (1994)[181]. He divides four aspects: international, national, regional, individual. And he discusses seven parts of tourism politics (role of government in tourism; tourism policy; tourism and international relationship; travel, violence and revolution; tourism and development; tourism, ideology, political socialization with the change in value; tourism in capitalist society), which lays foundation for later studies' theme.

The existing study on tourism carrying capacity has already been conducted from the environment, economics, political science, sociology and other disciplines, either from the angle of modeling (such as LAC, VERP, VIM, VAMP, ROS, TOMM, PAVIM) or case study (such as Cifuentes et al., 1990;[182] Papageorgiou & Brotherton, 1999;[183] Sowman, 1987;[184] Saveriades, 2000;[185] Symmonds et al., 2000;[186] Tarrant & English, 1996;[187] De Ruyck, 1997[188]). But the research on the cities especially on Asian cities as the background of UTCC study is still in its initial stage.

From CC to TCC and then to UTCC, from the view of vertical development of the discipline, it shows the in-depth and refinement research of CC from the initial simple ecology animal husbandry gradually to complex human society. The study development is due to not only the development of the discipline itself and but also the development of mathematical theory. From the view of crosswise development of the discipline, the modern research of UTCC has involved tourism, ecology, sociology, political science and other subjects. The research object also contains more complex attributes than before. How to study UTCC with an open platform including the multiple attribute collection are both the direction of the theory and the purpose of this article.

[177] Kuo, I. L. (2002). The Effectiveness of Environmental Interpretation at Resource-Sensitive Tourism Destinations. *International Journal of Tourism Research*, 4, 87-101.
[178] Ajuntament de Calvia Mallora. (1999). *The Sustainability of a Tourist Municipality. Plan of Action. 10 Strategic Lines of Action and 40 Initiatives*, Calvia Agenda 21, Calvia.
[179] Borg, J. van der, Costa, P., Manente, M. (1993). *Traditional Tourism Cities: Problems and Perspectives*. CISET Working Paper, University of Venice. 12-16.
[180] Wang, H. (1996), A systematic Approach to Natural Recreational Resource Management. *Socio-Economic Planning Science*, 30(1), 39-49.
[181] Hall, C. M. (1994). *Tourism and Politics: Policy, Power and Place*. Chichester, U. K.: Wiley.
[182] Cifuentes, M., Alpizar, W., Barroso, F., Courrau, J., Falck, M. L., Jimenez, R., Ortiz, P., Rodriguez, J., Romero, J. C., Tejada, J. (1990). Ibid., p. 25.
[183] Papageorgiou, K., Brotherton, I. (1999). Ibid., p. 25.
[184] Sowman, M. (1987). Ibid., p. 25.
[185] Saveriades, A. (2000). Ibid., p. 25.
[186] Symmonds, M. C., Hammitt, W. E., Quisenberry, V. L. (2000). Ibid., p. 25.
[187] Tarrant, M. A., English, D. B. K. (1996). Ibid., p. 25.
[188] De Ruyck, M. C., Soares, A. G. et al. (1997). Ibid., p. 25.

Chapter 3

Concept Definition and Theory Establishment of
Urban Tourism Carrying Capacity (UTCC)

3.1 Concept Definition of UTCC

The academic community has not clearly defined UTCC, but the current researches can be divided into two schools, one is represented by WTO (1999)[189], Li Tianyuan (2001)[190] and Li Junyi (2001)[191] who focus on the maximum number of tourists the destination can attract in a certain time period, with the premise that local environment, natural, economic and social cultures have no crisis and tourist satisfaction will not decrease.

The other is represented by Coccossis (2002)[192], Castellani et al. (2007)[193] and Tang Xianghui (2001)[194], promoting the maximum utilization of local tourism resources with the premise that negative influence will be caused on resources, the local society, economy and culture will not be influenced and tourist satisfaction will not decrease. The two expressions reveal two research perspectives. The former focuses on the number of tourists, while the latter is more inclined to research the maximum utilizations of resources.

However, both the two schools research the harmonious co-existence relation between the circumstances and the objects of tourism carrying capacity, and this balance relation can be investigate according to using degree of local resources or the number of environmental objects, but they are not contradictory, for the resources are foundation and determine the environmental objects' carrying capacity which can be intuitive reflected by investigation on the number of environmental objects.

Although there is no clear definition for UTCC in academic circles, according to the two kinds of CC research perspectives of ecology mentioned above, this paper tries to state UTCC as follows.

UTCC refers to the maximum utilization of the city tourism elements without causing unacceptable negative influence to the elements, quality of tourist experience of visitors, and quality of residents' daily life, measure of which is by the maximum capacity number of tourists that can be accommodated by each related city tourism element.

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[189] World Tourism Organization. (1999). *Global code of ethics for tourism*. Proc. of Thirteenth session of General Assembly: Santiago, Chile.

[190] 李天元. (2001). 关于旅游承载力理论应用问题的思考. 南开商业评论, 4(3), 57-60.

[191] 李君轶. (2001). 旅游地理学研究重点及发展趋势分析. 陕西师范大学继续教育学报(西安), 18(4), 116-118.

[192] Coccossis, H. (2002). Tourism Development and Carrying Capacity. *Island Tourism and Sustainable Development: Caribbean, Pacific and Mediterranean Experiences*, Praeger, Westport, Connecticut, 131-144.

[193] Castellani, V., Sala, S., Pitea, D. (2007). *A new method for tourism carrying capacity assessment*. Ecosystems and Sustainable Development, VI, 365-374.

[194] Tang Xianghui. (2001). A Study on the Development of Tour Economy in the Western Regions of China. *Journal of Hunan Agricultural University*, 2(1), 17-20.

3.2 Theory Establishment of UTCC

UTCC is the extension of CC research to city as a carrier in tourism field, with the theory based on CC research, inspecting the maximum utilization of city tourism elements (environment, society, economy etc.) without causing any unacceptable negative influence on them.

From the perspective of the visible supply of the tourism resource (physically), UTCC includes many kinds of resources that relate to tourism such as ecological environment resources, artificial facilities resources, all kinds of enterprises and product resources, human resources and so on, which restricts UTCC from physical level. If one of the resources is damaged and reduces the carrying capacity to either visitors or residents for some reason, it will directly trigger an exclusionary effect which is often swift and violent, such as less accommodation in holidays.

From the perspective of the invisible supply of tourism resources (non-physically), it mainly includes the resident social psychological situation, city politics & policy orientation, service quality of city tourism, the opening degree of city original cultural practices.

These invisible resources also affect both of the residents and tourists. Though it has no direct impact on them, the non-physical mental constraints can affect both the residents and tourists as a form of negative cumulative effect indirectly. If it accumulates to a certain extent as time passes, it will be seriously dangerous to the whole society for the appearing of distrust events between groups of residents and visitors, and the butterfly effect will spread to other industries of the city and cause a sharp decline to the overall image of the city. Examples are as the distrust events between groups of visitors and residents occurred in Sanya, China and the incident of the tour guide's swearing at tourist also leads to considerable negative effects on the tourism market of Hong Kong.

Based on the above considerations, this paper tries to establish UTCC theory from 3 aspects:

(1) Urban Facilities–Environmental Tourism Carrying Capacity (U F & En TCC)

U F & En TCC refers to the maximum utilization of the urban F & En elements without causing unacceptable negative influence to the elements, quality of tourist experience of visitors, and quality of residents' daily life, measure of which is by the maximum capacity number of tourists that can be accommodated by urban F & En elements.

The definition of U F & En TCC includes two meanings: one is associated with the carrying capacity of urban tourism infrastructure (such as hotels, restaurants, tourist service centers, etc.) or its products (such as water supply, power supply, gas and other resources). The other one is the carrying capacity of urban natural ecological elements (such as the city green space, air, etc.).

(2) Urban Social–Cultural Tourism Carrying Capacity (U S & C TCC)

U S & C TCC refers to the maximum utilization of the urban S & C elements without causing unacceptable negative influence to the elements, quality of tourist experience of visitors, and quality of residents' daily life, measure of which is by the maximum capacity number of tourists that can be accommodated by urban S & C elements.

Social and cultural factors both belong to the spiritual level and have a high correlation with each other, specifically, to its classification and definition needed to be further studied. Urban social cultural factors mainly include the city's unique folk customs, inheriting, inclusion-exclusion of foreign and local tourists, social psychology of the city population and so on.

(3) Urban Political–Economic Tourism Carrying Capacity (U P & Ec TCC)

U P & Ec TCC refers to the maximum utilization of the urban P & Ec elements without causing unacceptable negative influence to the elements, quality of tourist experience of visitors, and quality of residents' daily life, measure of which is by the maximum capacity number of tourists that can be accommodated by urban P & Ec elements.

Political factor mainly refers to the influence of the urban tourism by policies and political events triggered by policies. Economic element refers to the impact of economic development on the urban tourism industry, including the investment scale of urban tourism, urban economic scale, citizens' tourism consumption and so on.

3.3 Index System

UTCC study is a large project, according to the relationship between the levels of each increasing layer, indexes inspecting system can be established as that in table 3-1.

Table 3-1. Index System of UTCC

Level(I)	Level(II)	Level(III)	Level(IV)
U T C C	U F & En TCC(II$_1$)	U F TCC(III$_1$)	U F$_1$ TCC
			…
			U F$_m$ TCC
		U En TCC(III$_1$)	U En$_{m+1}$ TCC
			…
			U En$_n$ 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

Chapter 4

Modeling of UTCC

4.1 Introduction of Methodology

Of all the existing indexes, some can be quantitatively studied (such as the indexes related with environment and facilities), some cannot (such as social psychological and cultural indexes). Therefore, different indexes should be analyzed with different methods.

In this paper, physical quantitative indexes are analyzed with FAHP (Zhang Bo, 2007)[195] combined with MOM (Deb K., 2001)[196], while the non - physical indexes are analyzed with SRS (UNFCC, 2009)[197] combined with FAHP, so as to review people's subjective ideology.

This chapter finally introduces how to correct quantitative analysis results with qualitative analysis so as to get the comprehensive evaluation value of UTCC. Specific analysis process is as shown in figure 4-1.
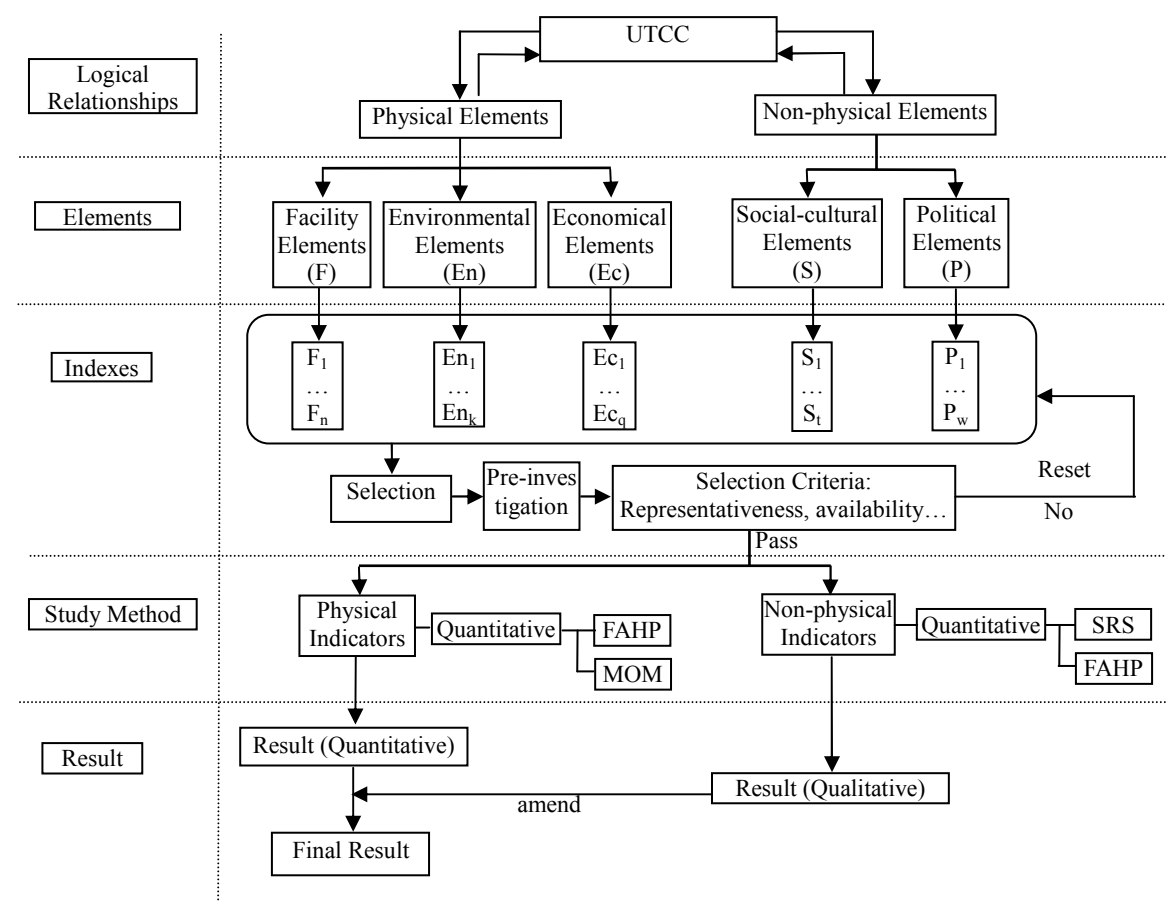
Figure 4-1. Analysis Flowchart of UTCC

[195] Zhang Bo, Wang Jieping. (2007). City tourism competitiveness analyzed by fuzzy comprehensive evaluation. *East China Economic Management*, 21(10), 145-148.
[196] Deb, K. (2001). *Multi-Objective Optimization using Evolutionary Algorithms, Wiley-Interscience Series in Systems and Optimization*. John Wiley & Sons.
[197] UNFCC. (2009). *General guidelines on sampling and surveys for small-scale CDM project activities (Version 1.0)*. Report EB 50, 1-9.

4.2 Mathematical Analysis

(1) Introduction of Triangular Fuzzy Analytic Hierarchy Process (FAHP)

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

The investigation is divided into two parts. One is to evaluate the weights of indexes, namely, to find out to what extent the indexes influence the social psychological carrying capacity of the residents in tourism destination via expert questionnaire survey; the other is to comprehensively evaluate their social psychological carrying capacity according to raised questions.

The process is as follows:

Definition: M is a triangular fuzzy number (TFN) which belongs to a special class of fuzzy number whose membership is defined by three real numbers, expressed as M (l, m, u). The triangular membership function is represented as follows.

$$M(x) = \begin{cases} (x-l)/(m-l) & l \le x \le m \\ (x-u)/(m-u) & m \le x \le u \\ 0 & others \end{cases} \quad (l,m,u \in R, l \le m \le u) \quad (1)$$

The operational laws between two triangular fuzzy numbers $M_1=(l_1,m_1,u_1)$ and $M_2=(l_2,m_2,u_2)$ are as follows.

$$M_1 \oplus M_2 = (l_1+l_2, m_1+m_2, u_1+u_2) \quad (2) \quad M_1 \otimes M_2 \approx (l_1 l_2, m_1 m_2, u_1 u_2) \quad (3)$$

$$\lambda \times M = (\lambda l, \lambda m, \lambda u) \quad \lambda > 0 \quad (4) \quad M_1 - M_2 = (l_1-l_2, m_1-m_2, u_1-u_2) \quad (5)$$

$$(l,m,u)^{-1} = (1/u, 1/m, 1/l) \quad (6)$$

Where $\oplus$ 、 $\otimes$ represent addition and multiplication operators of the fuzzy numbers.

The standards to evaluate weight of two index groups, the meaning, the language variable system and corresponding triangle fuzzy numbers are listed in Table 4-1[198], and the upper and lower limits (l and u) of triangle fuzzy numbers to evaluate weight of two index groups are in (1/2, 1) (Zhu Kejun et al., 1999)[199].

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[198] Chang P L, Chen Y C. (1994). A fuzzy multi-criteria decision making method for technology transfer strategy selection in biotechnology. *Fuzzy Sets and Systems*, 63(2), 131-139.
[199] Zhu Kejun, Yu Jing, Chang Dayong. (1999). A discussion ion extent analysis method and applications of fuzzy AHP. *European Journal of Operational Research*, 116, 450-456.

Table 4-1. Scale of Index Weight, Linguistic Value and Corresponding TFNs

Weight	Relative Importance of the Two Indicators (r_i & r_j)	Language Variable System of the Indicators	Corresponding TFNs
1	r_i and r_j are equally important	Significant Negative Impact.	(0,0,0.25)
3	r_i is slightly important than r_j	Some Negative Impacts.	(0,0.25,0.5)
5	r_i is important than r_j	No Impact.	(0.25,0.5,0.75)
7	r_i is strongly important than r_j	Some Positive Impacts.	(0.5,0.75,1)
9	r_i is very strongly important than r_j	Significant Positive Impact.	(0.75,1,1)
2,4,6,8	Intermediate values between the two adjacent judgments.		

① To construct judgment matrix of the index weight of triangular fuzzy number

Through comparison, fuzzy judgment matrix (R) of index weight is:

$$R=[\frac{1}{v}\times\sum_{k=1}^{v}(r_{ij}^{(q)})_k]_{n\times n} \quad \begin{array}{l} (q=I,II,III) \\ (k=1,2,\cdots v) \\ (i,j=1,2,\cdots,n) \end{array} \quad (7)$$

Where q is the index level, n means the number of indexes, v says the number of experts, r_{ij} means the importance degree of index i to index j (i and j belong to the same index level, meaning the triangle fuzzy numbers corresponding to weight language value variable).

According to the formula (5) and (7), fuzzy judgment matrix R is transferred into fuzzy complementary matrix which is the mentioned matrix in the following part.

$$\begin{cases} r_{ij}=1/r_{ji}=(1/u_{ji},1/m_{ji},1/l_{ji}) & \text{when } r_{ji} \text{ exist} \\ r_{ji}=1/r_{ij}=(1/u_{ij},1/m_{ij},1/l_{ij}) & \text{when } r_{ij} \text{ exist} \end{cases} \quad (8)$$

② To check the consistency of judgment matrix

Consistency testing is to check the coordination of importance of elements, so as to avoid the contradiction that A is more important than B which is more important than C, while C is more important than A.

In consistency test of fuzzy number matrix, the triangular fuzzy numbers can be transferred into non-fuzzy numbers with the formula (8), to construct nonlinear fuzzy judgment matrix A, then consistency of A is evaluated according to the formula (9).

$$M_{\bar{t}}=\frac{l+4m+u}{6} \quad M_{\bar{t}} \text{ is the non-fuzzy number } M(l,m,u) \text{ corresponds to} \quad (9)$$

$$CR=\frac{\lambda_{max}(A)\text{-}n}{RI\times(n\text{-}1)} \quad (10)$$

Where CR is the ratio of random consistency of matrix A, λ max (A) is the largest eigen-values of matrix A, n is the number of matrix order, mean random consistency index RI is constant (Table 4-2). If CR<0.1, the matrix consistency test is qualified, or, comparative matrix needs constructing.

Table 4-2. R.I. Value of the Matrix with a High Order

Order	1	2	3	4	5	6	7	8	9	10
R.I. Value	0	0	0.52	0.89	1.12	1.26	1.36	1.41	1.46	1.49
Order	11	12	13	14	15	16	17	18	19	20
R.I. Value	1.52	1.54	1.56	1.58	1.59	1.59	1.61	1.61	1.62	1.63
Order	21	22	23	24	25	26	27	28	29	30
R.I. Value	1.64	1.65	1.65	1.66	1.66	1.66	1.67	1.67	1.67	1.67

③The calculation of comprehensive importance index value

$$S_i^{(q)} = \sum_{j=1}^{n} r_{ij}^{(q)} \otimes [\sum_{i=1}^{n} \sum_{j=1}^{n} r_{ij}^{(q)}]^{-1} \quad (q=I,II,III;\ i,j=1,2,\cdots n) \quad (11)$$

S_i is the value of comprehensive importance degree of the i*th* index to all other indexes (of the same level) in fuzzy judgment matrix, q means the number of matrix order, r_{ij} means the importance degree of index i to index j.

④Normalization of index weight value

Processing of index weight normalization can be performed in the following manner:

$M_1=(l_1,m_1,u_1)$, $M_2=(l_2,m_2,u_2)$ are two TFNs, $P(M_1 \geq M_2)$ is the possibility that $M_1 \geq M_2$.

At the time $m_1 < m_2$,

$$P(M_1 \geq M_2) = \begin{cases} \dfrac{l_2 - u_1}{m_1 - u_1 - (m_2 - l_2)} & l_2 < u_1 \\ 0 & l_2 \geq u_1 \end{cases} \quad (12)$$

At the time $m_1 > m_2$, $P(M_1 \geq M_2) = 1$ (13)

Make d shows the pure estimation that an evaluation index is superior to another, then,

$$\begin{aligned} d'(B_i^{(q)}) &= P(M_i^{(q)} \geq M_1^{(q)}, M_2^{(q)}, \cdots, M_{i-1}^{(q)}, M_{i+1}^{(q)}, \cdots, M_n^{(q)}) \\ &= \min P(M_i^{(q)} \geq M_k^{(q)}) \\ &\quad (k=1,2,\cdots,n, \quad k \neq i, \quad q=I.II.III) \end{aligned} \quad (14)$$

The entire weight vector of evaluation index:

$$W' = (d'(B_1^{(q)}), d'(B_2^{(q)}), \cdots, d'(B_n^{(q)}))^T \quad (15)$$

After normalization processing, weighted value of evaluation index can be expressed as follows:

$$W = (d(B_1^{(q)}), d(B_2^{(q)}), \cdots, d(B_n^{(q)}))^T \quad (16)$$

Where:

$$d(B_i^{(q)}) = \frac{d'(B_i^{(q)})}{d'(B_1^{(q)}) + d'(B_2^{(q)}) + \cdots + d'(B_n^{(q)})} \quad (i = 1, 2, \cdots, n, \quad q = \text{I,II,III}) \quad (17)$$

⑤Calculation of evaluation value of total target

Let $X = x_{m \times n}$, saying evaluation matrix of average triangular fuzzy number of m respondents to n indexes, then evaluation value of the tth layer target Q_t is expressed as:

$$Q_t = \sum_{i=1}^{m} x_i^{(q)} \otimes d(B_i^{(q)})$$
$$= x_1^{(q)} \times d(B_1^{(q)}) + x_2^{(q)} \times d(B_2^{(q)}) + \cdots + x_m^{(q)} \times d(B_m^{(q)})$$

(t is the target level，q=I,II,III) (18)

The triangular fuzzy numbers cannot be compared, and the results can be transferred into non fuzzy numbers with formula (9) for comparative study (Guo Yuxia, 2008)[200].

(2) Introduction of the Multi-objective Optimization Method (MOM)

MOM is first raised by American mathematician Charles and Cooper in 1961(Deb K., 2001)[201]. It provides an open and continuous research platform for UTCC study. Many resource elements are regarded as the object or model constraint. Independent object itself can also be researched with many kinds of ways and can also be transferred between the requirement and object if needed in the study, so as to further study the object with different constraints.

Based on the index weight matrix by FAHP, MOM can be used for the index value modeling, model is as follows:

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

$$\begin{cases} \sum_{j=1}^{n} C_{ij} \times X_j + d_i^- - d_i^+ = g_i \quad (i = 1, 2, \cdots, h) \\ \sum_{j=1}^{n} a_{ij} \times X_j \le b_t \quad b = h+1, h+2, \cdots, m \quad (19) \\ X_j \ge 0 \quad (j = 1, 2, \cdots, h) \\ d_i^+ \ge 0, \quad d_i^- \ge 0, \quad i = 1, 2, \cdots, m \end{cases}$$

Where,
X_j as the decision variable;
d_i^+, d_i^- for the positive and negative deviations;
C_{ij} for the coefficient of X_i of the ith constraint;
a_{ij} for the X_j coefficient of tth resource constraints, general for each resource unit

[200] Gong Yuxia. (2008). Triangular Fuzzy Number Comprehensive evaluation Method of Financial Mixed-Business Management. *Journal of Luoyang Normal University*, 2, 170-172.
[201] Deb, K. (2001). Ibid., p. 36.

consumption quota;

    g_i for the established value of ith object;

    b_t for the limit value of tth resource constraint;

    P_k for target priority level, it only shows the different target sequence, the priority is usually determined by the decision maker;

    $w_{ki}d_i^-$, $w_{ki}d_i^+$ for the weighting coefficient of d_i^-, d_i^+ of kth class.

(3) Introduction of Stratified Random Sampling (SRS)

Stratified random sampling method is widely used for larger-range surveys, such as census, ratings, large-scale disease investigation, for the method is advantageous to reflect overall characteristics with small sample, with flexible implementation and higher precision of investigation.

    ① To determine the number of layers

"Layer" can be defined that, if the population can be divided into some non-overlapped and exhaustive subsets, i.e. each unit will belong to one and only one subpopulation, and then this subpopulation is named as layer. In practice, the investigated objects can be divided into different layers according to region, gender, age, department and other different attributes.

    ② To determine the total sample and the sample in each layer

The total sample n from stratified random sampling is determined according to survey accuracy, cost constraints, the estimated statistics and the sample distribution.

If $\overline{Y}$ is the mean of population, V is the upper limit of variance of given estimator (or d is the absolute error limit of confidence 1- α and $d^2 = u_\alpha^2 V$ is standard normal distribution confidence), general precision is the absolute error limit of d to $\overline{y}_{st}$ (under given reliability), i.e. $1-\alpha \le P\left[\left|\overline{y}_{st} - \overline{Y}\right| \le d\right]$. Then, if the sample distribution on each layer is realized according to proportional allocation method, the total sample n will be:

$$n = \frac{\sum_h W_h S_h^2}{\dfrac{d^2}{u_\alpha^2} + \dfrac{1}{N}\sum_h W_h S_h^2} \quad (20)$$

    n: the total sample population

    h: the number of layers

    W_h: layer weights ($W_h = N_h/N$, where N_h is unit number of the hth layer)

    S_h^2: sample variance of the hth layer

    d: permissible error

    u_α: α quantile in standard normal distribution (when n>30, t distribution can be viewed as a normal distribution, and the critical values are shown in Table 4-3.)

    N: population

Table 4-3. Critical Value of t-Distribution

Significant Level (α)	0.01	α=0.02	α=0.05	α=0.1	α=0.2	α=0.32	α=0.5
Confidential Degree (1-α)%	99%	98%	95%	90%	80%	68%	50%
t Value	2.58	2.33	1.96	1.64	1.28	1	0.67

(4) Combined qualitative research and quantitative research

Qualitative research and quantitative research can be combined in three ways.

① Theil (1971)[202] proposed to correct qualitative analysis with quantitative analysis. Qualitative prediction is firstly finished, and then it will be corrected by quantitative analysis. The prediction results are largely affected by the forecaster's knowledge and experience, so qualitative prediction can show system errors and regression deviation. After the qualitative prediction, system error and regression deviation in qualitative prediction are eliminated with regression analysis.

② The Clemen (1959)[203] proposes to integrate qualitative analysis into quantitative analysis. The qualitative prediction results are integrated into quantitative model. The model overall goal is respectively affected by qualitative and quantitative analysis, with no correlation, leading to independent results.

③ At present, in addition to the integrated qualitative prediction and quantitative prediction mentioned above, to correct qualitative analysis with quantitative methods (Lim, O'Connor, 1995)[204] is also promoted, and it is easier in application.

Firstly, prediction is realized with quantitative methods, and then qualitative methods are adopted to correct quantitative prediction results. The trend is firstly assumed to be unchanged, then quantitative method is used to make prediction, then qualitative method is for modification, to judge the trend, upward or downward, and finally comprehensive analysis and prediction are made. The method also has its disadvantages, for forecasters pay less attention to qualitative prediction and focus on their qualitative prediction.

To correct quantitative prediction with qualitative prediction does not mean to replace the former with the latter, so it should be carefully implemented. Generally, if the quantitative research results contain the elements difficult to be studied with quantitative methods (qualitative elements) the qualitative research results shall be revised with quantitative investigation. In order to avoid over-frequent revision of quantitative prediction, the policy makers should carefully consider the following 3 questions:

(I) Whether to modify?

This is the first question to be thought over when policy makers consider quantitative prediction results, and its default answer is "no change", so as to prevent easily

[202] Theil, H. (1971). *Applied Economic Forecasting*. North-Holland Publishing Company, 243.
[203] Clemen, R.T. (1989). Combining forecasts: A review and annotated bibliography. *International Journal of Forecasting*, 5, 501.
[204] Lim, J., O'Connor, M. (1995). Judgmental adjustment of initial forecasts-its effectiveness and biases. *Journal of Behavioral Decision Making*, 8, 149.

modification of the quantitative prediction results.

(II) The reasons for adjustments?

It aims to minimize unnecessary adjustment. The list of reasons for adjustment of quantitative models will help the decision makers to clarify systematic ideas.

(III) Adjustment degree?

This question is to enable decision makers to consider carefully adjustment degree of the quantitative forecast, with no abandoning quantitative prediction results and repeating qualitative prediction.

In view of the above description, this study adopts the third method for the following reasons:

Factors influencing UTCC can be divided into two groups, including physical factors that can be studied with quantitative method and non-physical factors which are difficult to be studied with quantitative method and require qualitative methods. But these two kinds of factors both affect the UTCC.

According to the philosophical perspectives, the material determines ideology, but the latter will counterproductively affect the former. For the UTCC, physical-layer elements determine the strength of carrying capacity and play a decisive role on current UTCC or in a period of time, while the nonphysical factors (mainly of the spirit level) will influence UTCC in the future. The two layers complement each other.

Therefore, in investigation of UTCC, elements of physical and non physical layer shall be comprehensively investigated. In this study, the results of qualitative research on non-physical elements are adopted to correct the quantitative research results of physical elements.

4.3 Function and evaluation of the model

The UTCC model has two basic functions: one is, according to the constraint elements of historical data, to examine the past UTCC, and the other is to predict the future situation based on this model. Two methods can be used to make the prediction, one is, based on its historical data of respective constraint factor to make predictions curve and get predictive value, finally make a summary with the model and obtain the total predictive value. The other one is, based on the total target value, to make forecast curve and obtain the predicted future value.

The former is suitable for quantitative study of the index prediction, while the latter is comprehensive, and suitable for examining the future UTCC from perspective of development and change, and for the non-quantitative study of index prediction.

For evaluation of the model, it is mainly based on the multiple related parameters and functions of the model value and the actual value fitting curves from different angles to evaluate the UTCC model. Related parameters and functions mainly have the curve

fitting correlation coefficient (r) (Ding Sitong et al., 2006)[205], curve line spacing function (d), and curve surround area function (S).

Curve fitting correlation coefficient (r) mainly describes the correlation between the model data fitting curve and the actual data fitting curve, being used to describe the relationship between the UTCC and the actual number of tourists along with the time development trend. It is to judge the overall trend of the model's fitting curve, $r \in [-1,1]$. When $r \in (0,1)$, it shows that the model curve and actual curve has a positive correlation to some degree. When $r \in (-1,0)$, it shows that model curve and actual curve has a certain negative correlation to some degree. When $|r|=1$, it is the completely linear relationship, and for the value of $|r|$, the closer to 1, the closer the linear relationship is. When $|r|=0$, there is no line relationship, the closer to 0, the more weakly the linear relation is.

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 utilization of the urban tourism resource in reality，$d \in (-\infty,+\infty)$. When $d \in (0,+\infty)$, the model value is greater than actual value, it means there is still development room for urban tourism.

But if d has a high value in the positive range, it also indicates that the urban does not have very good use of the tourism resources to promote its tourism development. When $d \in (-\infty,0)$, it illustrates the actual value exceeds the model value and the urban resources have been overloaded by tourists. The smaller the value of d is in negative, the worse the overload situation is; when $d=0$ (the theoretical value) or in the vicinity of a small range (actual value) represents model value and the actual value are generally corresponding, and the urban resources are fully utilized. In addition, d can be flexible to change to illustrate the state of UTCC in different time periods under different conditions.

The surrounding area function (S) of the curves shows the encircled area by model curve and actual curve in a specific period. It describes the difference between city tourism carrying capacity and the actual number of visitors during a certain period of time. The value of S is positive, which means the city tourism carrying capacity is larger than the actual number of visitors. While, when the value of S is negative it means the city tourism carrying capacity is smaller than the actual number of visitors. Within a certain period of time, the S integral value of surround area represents the difference value between the total number of city carrying tourists and the actual total number of tourists.

The slope of the curve (k) is the tangent value of the angle between curve's tangent line and the x-axis. It describes the intensity of the curve trends (rise or fall). If slope of the model value fitting curve k_M (or the slope of the actual value fitting curve k_A) represents a positive value, in another words, the tangent value of the angle between curve's tangent line and the x-axis is positive, means the trend of the UTCC (or the actual tourist number) is to increase in the future.

[205] Ding Sitong, Liao Weiming, Dong Jun, Yang Yonghong. (2006). Evaluation and the Examination of the Mathematics Models. *Acta Agriculturae University Jiangxiensis*, 4, 641-644.

Otherwise, it is decrease. $k_A<k_M$ represents the slope of the model value fitting curve is greater than the actual value curve, which means the growth trend of UTCC is faster than the tourist number, or the decreasing trend of UTCC is slower than the tourist number. Similarly, $k_M<k_A$ reflects the slope of the model value fitting curve is smaller than the actual value curve, which means the growth trend of UTCC is slower than the tourist number, or the decreasing trend of UTCC is faster than the tourist number.

The line integrated by the assumed model value and actual value is a straight line. The horizontal axis represents the time, and the longitudinal axis represents the number, thus the sample graph and related parameters are described in Figure 4-2 to Figure 4-17 shown below.
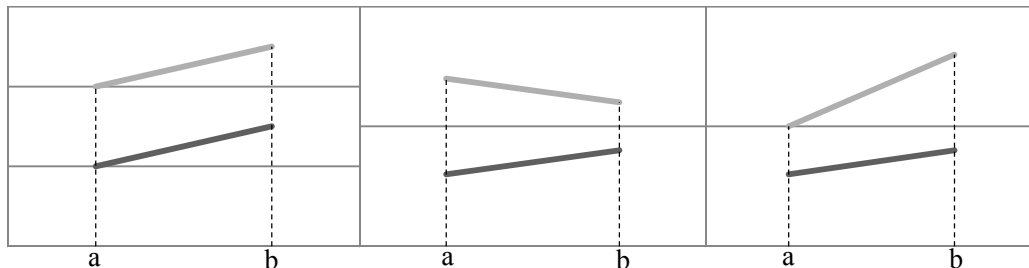
Figure 4-2.
$r=1$, $0<k_A=k_M$
$d>0$, $S(x)|_a^b > 0$

Figure 4-3.
$-1<r<0$, $k_M<0<k_A$
$d>0$, $S(x)|_a^b > 0$

Figure 4-4.
$0<r<1$, $0<k_A<k_M$
$d>0$, $S(x)|_a^b > 0$
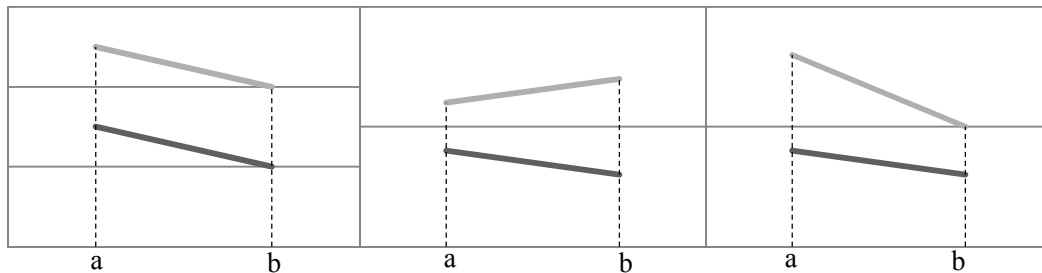
Figure 4-5.
$r=1$, $k_A=k_M<0$
$d>0$, $S(x)|_a^b > 0$

Figure 4-6.
$-1<r<0$, $k_A<0<k_M$,
$d>0$, $S(x)|_a^b > 0$

Figure 4-7.
$0<r<1$, $k_M<k_A<0$
$d>0$, $S(x)|_a^b > 0$
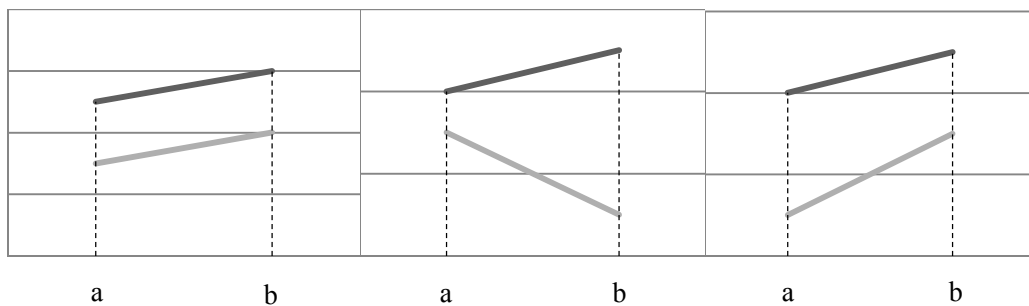
Figure 4-8.
$r=1$, $0<k_A=k_M$
$d<0$, $S(x)|_a^b < 0$

Figure 4-9.
$-1<r<0$, $k_M<0<k_A$
$d<0$, $S(x)|_a^b < 0$

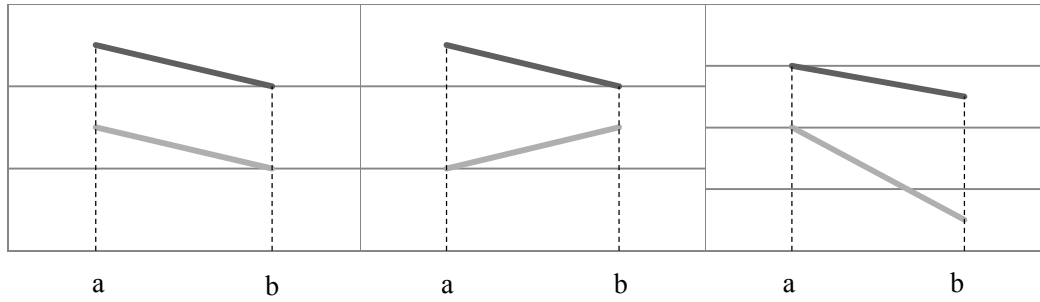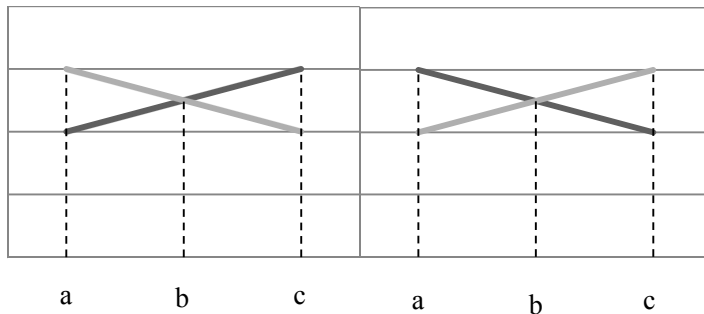**Figure 4-10.**
$0<r<1$, $0<k_A<k_M$
$d<0$, $S(x)|_a^b < 0$

Figure 4-11.
r=1, $k_A = k_M < 0$
d<0, $S(x)|_a^b < 0$

Figure 4-12.
-1<r<0, $k_M < 0 < k_A$
d<0, $S(x)|_a^b < 0$

Figure 4-13.
0<r<1, $k_M < k_A < 0$
d<0, $S(x)|_a^b < 0$

Actual value
fitting curve

Model value
fitting curve

Figure 4-14.
-1<r<0; $k_M < 0 < k_A$
d>0, $S(x)|_a^b > 0$, x∈(a,b);
d<0, $S(x)|_b^c < 0$, x∈(b,c);

Figure 4-15.
-1<r<0; $k_A < 0 < k_M$
d<0, $S(x)|_a^b < 0$, x∈(a,b);
d>0, $S(x)|_b^c > 0$, x∈(b,c);
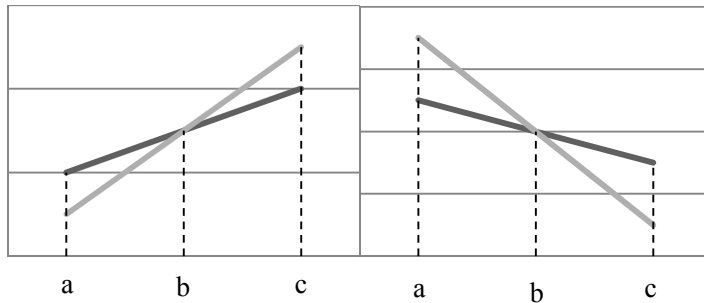
Figure 4-16.
0<r<1; $0 < k_A < k_M$
d<0, $S(x)|_a^b < 0$, x∈(a,b);
d>0, $S(x)|_b^c > 0$, x∈(b,c);

Figure 4-17.
0<r<1; $k_M < k_A < 0$
d>0, $S(x)|_a^b > 0$, x∈(a,b);
d<0, $S(x)|_b^c < 0$, x∈(b,c);

Figure 4-2. – Figure 4-17. Sample Graph and Related Parameters of Model and Actual Value Fitting Curves

Notes:

Figure 4-2

Curve fitting correlation coefficient r=1 describes the model fitting curve and the actual data fitting has a consistent trend as time passes. And both of the curves are show a positive consistent trend, which means the relationship between the UTCC and

the actual number of tourists has a positive correlation (completely linear relationship) along with the time development trend.

The slope of curves $0<k_A=k_M$ describes both of the intensity of the curve trends are rising and represent a positive value, and the growth trend of the two curves are in a same rate. In another words, the tangent value of the angle between curve's tangent line and the x-axis is positive, which means the trend of the UTCC and the actual tourist number will increase in the future and the growth trend is in a same rate.

Curve line spacing function d>0 reflects the model value is greater than actual value. Specially, d is a constant in this case and both of the curves show an increasing trend with a same rate as time passes. It means the rising trend of UTCC and the actual tourist number are increasing with a same pace, and there is still development room for urban tourism. But if d has a high value in the positive range, it also indicates that the urban does not have very good use of the tourism resources to promote its tourism development.

The surrounding area function of the curves $S(x)|_a^b > 0$ shows the encircled area by model value fitting curve and the actual value fitting curve during period of a and b is a positive value, which means the urban tourism carrying capacity is larger than the actual number of visitors, and they appeared an increasing trend within period of a and b.

Figure 4-3

Curve fitting correlation coefficient -1<r<0 describes the model fitting curve and the actual data fitting has an inconsistent trend as time passes. The model fitting curve shows a negative trend, while the actual value represents a positive trend, which means the relationship between the UTCC and the actual number of tourists has a negative correlation along with the time development trend.

The slope of curves $k_M<0<k_A$ describes the intensity of the curve trends is converse and the slope of the actual value fitting curve represents a positive value, while the slope of the model curve shows a negative value. In another words, the tangent value of the angle between the actual curve's tangent line and the x-axis is positive while the model curve is opposite, which means the trend of the UTCC and the actual tourist number will appear an opposite tendency in the future.

Curve line spacing function d>0 reflects the model value is greater than actual value, which means there is still development room for urban tourism. But the space is getting smaller for the slope of the two curve shows an opposite trend.

The surrounding area function of the curves $S(x)|_a^b > 0$ shows the encircled area by model value fitting curve and the actual value fitting curve during period of a and b is a positive value, which means the urban tourism carrying capacity is larger than the actual number of visitors within period of a and b. However, there is a similar tendency as the space between the two curves that the S value is getting smaller for the opposite trend of the two curves.

Figure 4-4

Curve fitting correlation coefficient 0<r<1 describes the model fitting curve and the actual data fitting has a consistent trend as time passes. And both of the curves are show a positive consistent trend, which means the relationship between the UTCC and the actual number of tourists has a positive correlation along with the time development trend.

The slope of curves $0<k_A<k_M$ describes both of the intensity of the curve trends are rise and represent a positive value, and the growth trend of model value fitting curve is faster than the actual value fitting curve. In another words, the tangent value of the angle between curve's tangent line and the x-axis is positive, which means the trend of the UTCC and the actual tourist number will increase in the future, and the growth trend of UTCC is faster than the tourist number.

Curve line spacing function d>0 reflects the model value is greater than actual value, which means there is still development room for urban tourism. And the space is getting larger for the slope of k_A is smaller than k_M.

The surrounding area function of the curves $S(x)|_a^b > 0$ shows the encircled area by model value fitting curve and the actual value fitting curve during period of a and b is a positive value, which means the urban tourism carrying capacity is larger than the actual number of visitors within period of a and b. Further, there is a similar tendency as the space between the two curves that the S value is getting larger for $k_A<k_M$.

Figure 4-5

Curve fitting correlation coefficient r=1 describes the model fitting curve and the actual data fitting has a consistent trend as time passes. And both of the curves are show a negative consistent trend, which means the relationship between the UTCC and the actual number of tourists has a negative correlation (completely linear relationship) along with the time development trend.

The slope of curves $k_A=k_M<0$ describes both of the intensity of the curve trends are going down and represent a negative value, and the growth trend of the two curves are in a same rate. In another word, the tangent value of the angle between curve's tangent line and the x-axis is negative, which means the trend of the UTCC and the actual tourist number will decrease in the future and the growth trend is in a same rate.

Curve line spacing function d>0 reflects the model value is greater than actual value. Specially, d is a constant in this case and both of the curves show a declining trend with a same rate with time passes by. It means the decreasing trend of UTCC and the actual tourist number are decreasing with a same pace. But if d has a high value in the positive range, it also indicates that the urban does not have very good use of the tourism resources to promote its tourism development.

The surrounding area function of the curves $S(x)|_a^b > 0$ shows the encircled area by model value fitting curve and the actual value fitting curve during period of a and b is a positive value, which means the urban tourism carrying capacity is larger than the actual number of visitors though they appeared a decreasing trend within period of a and b.

Figure 4-6

Curve fitting correlation coefficient $-1<r<0$ describes the model fitting curve and the actual data fitting has an inconsistent trend as time passes. The model fitting curve shows a positive trend, while the actual value represents a negative trend, which means the relationship between the UTCC and the actual number of tourists has a negative correlation along with the time development trend.

The slope of curves $k_A<0<k_M$ describes the intensity of the curve trends is converse and the slope of the actual value fitting curve represents a negative value, while the slope of the model curve shows a positive value. In another words, the tangent value of the angle between the actual curve's tangent line and the x-axis is negative while the model curve is opposite, which means the trend of the UTCC and the actual tourist number will appear an opposite tendency in the future.

Curve line spacing function $d>0$ reflects the model value is greater than actual value, which means there is still development room for urban tourism. But the space is getting lager for the slope of the two curve shows an opposite trend.

The surrounding area function of the curves $S(x)|_a^b > 0$ shows the encircled area by model value fitting curve and the actual value fitting curve during period of a and b is a positive value, which means the urban tourism carrying capacity is larger than the actual number of visitors within period of a and b. However, there is a similar tendency as the space between the two curves that the S value is getting lager for the opposite trend of the two curves.

Figure 4-7

Curve fitting correlation coefficient $0<r<1$ describes the model fitting curve and the actual data fitting has a consistent trend as time passes. And both of the curves are show a negative consistent trend, which means the relationship between the UTCC and the actual number of tourists has a negative correlation along with the time development trend.

The slope of curves $k_M< k_A<0$ describes both of the intensity of the curve trends are going down and represent a negative value, and the decrease trend of model value fitting curve is faster than the actual value fitting curve. In another word, the tangent value of the angle between curve's tangent line and the x-axis is negative, which means the trend of the UTCC and the actual tourist number will decrease in the future, and the deceasing trend of UTCC is faster than the tourist number.

Curve line spacing function $d>0$ reflects the model value is greater than actual value, which means there is still development room for urban tourism. And the space is getting larger for the slope of k_M is smaller than k_A.

The surrounding area function of the curves $S(x)|_a^b > 0$ shows the encircled area by model value fitting curve and the actual value fitting curve during period of a and b is a positive value, which means the urban tourism carrying capacity is larger than the actual number of visitors within period of a and b. Further, there is a similar tendency

as the space between the two curves that the S value is getting smaller for $k_M < k_A$.

Figure 4-8

Curve fitting correlation coefficient r=1 describes the model fitting curve and the actual data fitting has a consistent trend as time passes. And both of the curves are show a positive consistent trend, which means the relationship between the UTCC and the actual number of tourists has a positive correlation (completely linear relationship) along with the time development trend.

The slope of curves $0 < k_A = k_M$ describes both of the intensity of the curve trends are rising and represent a positive value, and the growth trend of the two curves are in a same rate. In another words, the tangent value of the angle between curve's tangent line and the x-axis is positive, which means the trend of the UTCC and the actual tourist number will increase in the future and the growth trend is in a same rate.

Curve line spacing function d<0 reflects the model value is smaller than actual value. Specially, d is a constant in this case and both of the curves show an increasing trend with a same rate as time passes. It means the rising trend of UTCC and the actual tourist number are increasing with a same pace, but there is no development room for urban tourism for the value of tourist number is larger than value of UTCC.

The surrounding area function of the curves $S(x)|_a^b < 0$ shows the encircled area by model value fitting curve and the actual value fitting curve during period of a and b is a negative value, which means the urban tourism carrying capacity is smaller than the actual number of visitors, and they appeared an increasing trend within period of a and b.

Figure 4-9

Curve fitting correlation coefficient -1<r<0 describes the model fitting curve and the actual data fitting has an inconsistent trend as time passes. The model fitting curve shows a negative trend, while the actual value represents a positive trend, which means the relationship between the UTCC and the actual number of tourists has a negative correlation along with the time development trend.

The slope of curves $k_M < 0 < k_A$ describes the intensity of the curve trends is converse and the slope of the actual value fitting curve represents a positive value, while the slope of the model curve shows a negative value. In another words, the tangent value of the angle between the actual curve's tangent line and the x-axis is positive while the model curve is opposite, which means the trend of the UTCC and the actual tourist number will appear an opposite tendency in the future.

Curve line spacing function d<0 reflects the actual value is greater than model value, which means there is no development room for urban tourism. And the space is getting lager for the slope of the two curve shows an opposite trend.

The surrounding area function of the curves $S(x)|_a^b < 0$ shows the encircled area by model value fitting curve and the actual value fitting curve during period of a and b is a negative value, which means the urban tourism carrying capacity is smaller than the

actual number of visitors within period of a and b. However, there is a similar tendency as the space between the two curves that the S value is getting lager for the opposite trend of the two curves.

Figure 4-10

Curve fitting correlation coefficient $0<r<1$ describes the model fitting curve and the actual data fitting has a consistent trend as time passes. And both of the curves are show a positive consistent trend, which means the relationship between the UTCC and the actual number of tourists has a positive correlation along with the time development trend.

The slope of curves $0<k_A<k_M$ describes both of the intensity of the curve trends are rise and represent a positive value, and the growth trend of model value fitting curve is faster than the actual value fitting curve. In another words, the tangent value of the angle between curve's tangent line and the x-axis is positive, which means the trend of the UTCC and the actual tourist number will increase in the future, and the growth trend of UTCC is faster than the tourist number.

Curve line spacing function $d<0$ reflects the model value is smaller than actual value, which means there is no development room for urban tourism. And the space is getting smaller for the slope of k_A is smaller than k_M.

The surrounding area function of the curves $S(x)|_a^b < 0$ shows the encircled area by model value fitting curve and the actual value fitting curve during period of a and b is a negative value, which means the urban tourism carrying capacity is smaller than the actual number of visitors within period of a and b. Further, there is a similar tendency as the space between the two curves that the S value is getting smaller for $k_A<k_M$.

Figure 4-11

Curve fitting correlation coefficient $r=1$ describes the model fitting curve and the actual data fitting has a consistent trend as time passes. And both of the curves are show a negative consistent trend, which means the relationship between the UTCC and the actual number of tourists has a negative correlation (completely linear relationship) along with the time development trend.

The slope of curves $k_A=k_M<0$ describes both of the intensity of the curve trends are going down and represent a negative value, and the growth trend of the two curves are in a same rate. In another word, the tangent value of the angle between curve's tangent line and the x-axis is negative, which means the trend of the UTCC and the actual tourist number will decrease in the future and the growth trend is in a same rate.

Curve line spacing function $d<0$ reflects the model value is smaller than actual value. Specially, d is a constant in this case and both of the curves show a declining trend with a same rate with time passes by. It means the decreasing trend of UTCC and the actual tourist number are decreasing with a same pace.

The surrounding area function of the curves $S(x)|_a^b < 0$ shows the encircled area by model value fitting curve and the actual value fitting curve during period of a and b is

a negative value, which means the urban tourism carrying capacity is smaller than the actual number of visitors within period of a and b.

Figure 4-12

Curve fitting correlation coefficient -1<r<0 describes the model fitting curve and the actual data fitting has an inconsistent trend as time passes. The model fitting curve shows a negative trend, while the actual value represents a positive trend, which means the relationship between the UTCC and the actual number of tourists has a negative correlation along with the time development trend.

The slope of curves $k_M < 0 < k_A$ describes the intensity of the curve trends is converse and the slope of the actual value fitting curve represents a negative value, while the slope of the model curve shows a positive value. In another words, the tangent value of the angle between the actual curve's tangent line and the x-axis is negative while the model curve is opposite, which means the trend of the UTCC and the actual tourist number will appear an opposite tendency in the future.

Curve line spacing function d<0 reflects the model value is smaller than actual value, which means there is no development room for urban tourism. And the space is getting smaller for the slope of the two curve shows an opposite trend.

The surrounding area function of the curves $S(x)|_a^b < 0$ shows the encircled area by model value fitting curve and the actual value fitting curve during period of a and b is a negative value, which means the urban tourism carrying capacity is smaller than the actual number of visitors within period of a and b. There is a similar tendency as the space between the two curves that the S value is getting smaller for the opposite trend of the two curves.

Figure 4-13

Curve fitting correlation coefficient 0<r<1 describes the model fitting curve and the actual data fitting has a consistent trend as time passes. And both of the curves are show a negative consistent trend, which means the relationship between the UTCC and the actual number of tourists has a negative correlation along with the time development trend.

The slope of curves $k_M < k_A < 0$ describes both of the intensity of the curve trends are going down and represent a negative value, and the decrease trend of model value fitting curve is faster than the actual value fitting curve. In another word, the tangent value of the angle between curve's tangent line and the x-axis is negative, which means the trend of the UTCC and the actual tourist number will decrease in the future, and the deceasing trend of UTCC is faster than the tourist number.

Curve line spacing function d<0 reflects the model value is smaller than actual value, which means there is no development room for urban tourism. And the space is getting larger for the slope of k_M is smaller than k_A.

The surrounding area function of the curves $S(x)|_a^b < 0$ shows the encircled area by model value fitting curve and the actual value fitting curve during period of a and b is

a negative value, which means the urban tourism carrying capacity is smaller than the actual number of visitors within period of a and b. Further, there is a similar tendency as the space between the two curves that the S value is getting smaller for $k_M < k_A$.

Figure 4-14

Curve fitting correlation coefficient $-1 < r < 0$ describes the model fitting curve and the actual data fitting has an inconsistent trend as time passes. The model fitting curve shows a negative trend, while the actual value represents a positive trend, which means the relationship between the UTCC and the actual number of tourists has a negative correlation along with the time development trend.

The slope of curves $k_M < 0 < k_A$ describes the intensity of the curve trends is converse and the slope of the actual value fitting curve represents a positive value, while the slope of the model curve shows a negative value. In another words, the tangent value of the angle between the actual curve's tangent line and the x-axis is positive while the model curve is opposite, which means the trend of the UTCC and the actual tourist number will appear an opposite tendency in the future.

Curve line spacing function $d > 0$ in the interval (a, b) reflects the model value is greater than actual value, which means there is still development room for urban tourism. But the space is getting smaller for the slope of the two curve shows an opposite trend. When x is in the interval of (b, c), curve line spacing function $d < 0$, which reflects the model value is smaller than actual value. It means there is no development room for urban tourism. And the space is getting lager for the slope of the two curve shows an opposite trend.

The surrounding area function of the curves $S(x)|_a^b > 0$ when x is in the interval of (a, b), which shows the encircled area by model value fitting curve and the actual value fitting curve during period of a and b is a positive value. It means the urban tourism carrying capacity is larger than the actual number of visitors within period of a and b. However, there is a similar tendency as the space between the two curves that the S value is getting lager for the opposite trend of the two curves.

When x is in the interval of (b, c), the surrounding area function of the curves $S(x)|_b^c < 0$ shows the encircled area by model value fitting curve and the actual value fitting curve during period of b and c is a negative value, which means the urban tourism carrying capacity is smaller than the actual number of visitors within period of b and c.

Figure 4-15

Curve fitting correlation coefficient $-1 < r < 0$ describes the model fitting curve and the actual data fitting has an inconsistent trend as time passes. The model fitting curve shows a positive trend, while the actual value represents a negative trend, which means the relationship between the UTCC and the actual number of tourists has a negative correlation along with the time development trend.

The slope of curves $k_A < 0 < k_M$ describes the intensity of the curve trends is converse and the slope of the actual value fitting curve represents a negative value, while the

slope of the model curve shows a positive value. In another words, the tangent value of the angle between the actual curve's tangent line and the x-axis is negative while the model curve is opposite, which means the trend of the UTCC and the actual tourist number will appear an opposite tendency in the future.

Curve line spacing function d<0 in the interval (a, b) reflects the model value is smaller than the actual value, which means there is no development room for urban tourism. But the space is getting smaller for the slope of the two curve shows an opposite trend. When x is in the interval of (b, c), curve line spacing function d>0, which reflects the model value is greater than actual value. It means there is still development room for urban tourism. And the space is getting lager for the slope of the two curve shows an opposite trend as time passes.

The surrounding area function of the curves $S(x)|_a^b < 0$ when x is in the interval of (a, b), which shows the encircled area by model value fitting curve and the actual value fitting curve during period of a and b is a negative value. It means the urban tourism carrying capacity is smaller than the actual number of visitors within this period. There is a similar tendency as the space between the two curves that the S value is getting smaller for the opposite trend of the two curves.

When x is in the interval of (b, c), the surrounding area function of the curves $S(x)|_b^c > 0$ shows the encircled area by model value fitting curve and the actual value fitting curve during period of b and c is a positive value, which means the urban tourism carrying capacity is greater than the actual number of visitors within period of b and c.

Figure 4-16

Curve fitting correlation coefficient 0<r<1 describes the model fitting curve and the actual data fitting has a consistent trend as time passes. And both of the curves are show a positive consistent trend, which means the relationship between the UTCC and the actual number of tourists has a positive correlation along with the time development trend.

The slope of curves $0<k_A<k_M$ describes both of the intensity of the curve trends are rise and represent a positive value, and the growth trend of model value fitting curve is faster than the actual value fitting curve. In another words, the tangent value of the angle between curve's tangent line and the x-axis is positive, which means the trend of the UTCC and the actual tourist number will increase in the future, and the growth trend of UTCC is faster than the tourist number.

Curve line spacing function d<0 in the interval (a, b) reflects the model value is smaller than the actual value, which means there is no development room for urban tourism. And the space of the two curves is getting smaller for the slope of the two curve shows an opposite trend. When x is in the interval of (b, c), curve line spacing function d>0, which reflects the model value is greater than actual value. It means there is still development room for urban tourism. And the space is getting lager also for the slope of the two curve shows an opposite trend as time passes.

The surrounding area function of the curves $S(x)|_a^b < 0$ when x is in the interval of

(a, b), which shows the encircled area by model value fitting curve and the actual value fitting curve during period of a and b is a negative value. It means the urban tourism carrying capacity is smaller than the actual number of visitors within this period. There is a similar tendency as the space between the two curves that the S value is getting smaller for the opposite trend of the two curves.

When x is in the interval of (b, c), the surrounding area function of the curves $S(x)|_b^c > 0$ shows the encircled area by model value fitting curve and the actual value fitting curve during period of b and c is a positive value, which means the urban tourism carrying capacity is greater than the actual number of visitors within period of b and c.

Figure 4-17

Curve fitting correlation coefficient 0<r<1 describes the model fitting curve and the actual data fitting has a consistent trend as time passes. And both of the curves are show a positive consistent trend, which means the relationship between the UTCC and the actual number of tourists has a positive correlation along with the time development trend.

The slope of curves $k_M < k_A < 0$ describes both of the intensity of the curve trends are going down and represent a negative value, and the decrease trend of model value fitting curve is faster than the actual value fitting curve. In another word, the tangent value of the angle between curve's tangent line and the x-axis is negative, which means the trend of the UTCC and the actual tourist number will decrease in the future, and the deceasing trend of UTCC is faster than the tourist number.

The surrounding area function of the curves $S(x)|_a^b > 0$ when x is in the interval of (a, b), which shows the encircled area by model value fitting curve and the actual value fitting curve during period of a and b is a positive value. It means the urban tourism carrying capacity is greater than the actual number of visitors within period of a and b. However, there is a similar tendency as the space between the two curves that the S value is getting smaller for the opposite trend of the two curves.

When x is in the interval of (b, c), the surrounding area function of the curves $S(x)|_b^c < 0$ shows the encircled area by model value fitting curve and the actual value fitting curve during period of b and c is a negative value, which means the urban tourism carrying capacity is smaller than the actual number of visitors within period of b and c.

Chapter 5

Application Study of the Model (Tokyo and Osaka for examples)

5.1 Evaluating Elements and Corresponding Index System

UTCC study is a large project, mainly constituted by U F&En TCC, U S&C TCC, U P&Ec TCC showed in chapter 4. According to the analysis of the influence elements and the relationship between the levels of each increasing layer, indexes inspecting system can be established as that in table 5-1.

Table 5-1. Index System of UTCC

Level(I)	Level(II)	Level(III)	Level(IV)
U T C C	U F&En TCC(II_1)	U F TCC(III_1)	U F_1 TCC
			…
			U F_m TCC
		U En TCC(III_1)	U En_{m+1} TCC
			…
			U En_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

Furthermore, in this study, the indexes inspecting system can be divided into physical and non-physical level, as is shown in table 5-2.

Indexes of the physical level include the U F TCC, U En TCC, and U Ec TCC, while the non-physical level is mainly constituted by U P TCC, U S TCC, and U C TCC. This classification method can be varied in two aspects. One is the change of classification method, the index groups can be researched with different classification methods, rather than just "physical" and "non-physical perspective.

On the other hand, the influencing factors are classified based on current classification method (physical and non-physical perspective), some factors may not be studied with methods corresponding to related elements. For example, of the economic elements, if the public's feelings toward economic situation shall be examined, the methods used for non-physical indexes shall be adopted.

To sum up, the specific research methods should be selected based on specific cases.

Table 5-2. Index System of UTCC

Level(I)	Level(II)	Level(III)		Level(IV)
U T C C	U F&En TCC(II$_1$)	U F TCC(III$_1$)	Physical level	U F$_1$ TCC
				...
				U F$_m$ TCC
		U En TCC(III$_1$)		U En$_{m+1}$ TCC
				...
				U En$_n$ TCC
	U P&Ec TCC(II$_3$)	U Ec TCC(III$_5$)		U S$_{n+1}$ TCC
				...
				U S$_k$ TCC
		U P TCC(III$_4$)	Non-physical level	U C$_{k+1}$ TCC
				...
				U C$_p$ TCC
	U S&C TCC(II$_2$)	U S TCC(III$_2$)		U P$_{p+1}$ TCC
				...
				U P$_q$ TCC
		U C TCC(III$_3$)		U Ec$_{q+1}$ TCC
				...
				U Ec$_t$ TCC

The application of physical indexes is studied based on relevant data published by government. The application of non-physical indexes is studied via questionnaire survey to collect the required data. Some key data (such as the number of visitors) can only be summarized with government at all levels as units.

However, questionnaire survey according to these qualitative indexes will require heavy workload beyond the ability of doctoral research. Therefore, physical indexes are studied according to the data published by Tokyo and Osaka governments, and the non-physical indexes are investigated via questionnaire survey in Bunkyo District, Tokyo.

The ideal results should be obtained based on qualitative and quantitative analysis, which is, however, stopped by feasibility. A tentative solution is offered to combination of quantitative analysis and qualitative analysis, for reference only, and it will be introduced in 5.4.

5.2 Application Study of the Physical Level (Tokyo and Osaka for Examples)

For the application study of the physical level, this article only chooses infrastructure elements, environmental factors and economic factors of Tokyo and Osaka which are associated with tourism in the year of 2009 to do the research (Table.5-3).

In the present study, city infrastructure element is the constraint of the model, environmental and economic elements are as the objects of the mode.

Table 5-3. UTCC Evaluating Elements and Corresponding Index System of Tokyo & Osaka

Level(I)	Level(II)	Level(III)	Corresponding Index	Maximum Capacity		Actual Amount	Per Capita Actual Volume*
Evaluating elements of UTCC in Tokyo (I)	Elements of Facilities Capacity (U F TCC) (II_1)	Accommodation supply (III_1)	Hotel beds number (beds / day)	T	146206	94595	——
				O	63190	4303	——
		Electric power supply (III_2)	Electric power supply facilities (kw2) **	T	64487000	59990000	1.2389
				O	34000000	27230000	2.9424
		Water supply(III_3)	water supply facilities (m3/day)	T	6859500	4408003	0.3144
				O	5665343	3225683	0.3653
		Sewer treatment capacity (III_4)	Sewage treatment facilities (m³/day)	T	7658450	5768271	0.4114
				O	3591055	2305103	0.2491
		Garbage treatment capacity (III_5)	Sludge incineration facilities (t/ day)	T	6660	1252	8.9296×10^{-5}
				O	1812	359	3.8782×10^{-5}
	Elements of environment Capacity (U E TCC) (II_2)	SO_2 capacity (III_6)	SO2(PPM)	T	0.04	0.002	1.4265×10^{-10}
				O	0.04	0.005	5.4029×10^{-10}
		NO_2 capacity(III_7)	NO2(PPM)	T	0.04	0.021	1.4978×10^{-9}
				O	0.04	0.022	2.3773×10^{-9}
		O_x capacity (III_8)	Ox (PPM)	T	0.06	0.030	2.1397×10^{-9}
				O	0.06	0.031	3.3498×10^{-9}
		SPM capacity (III_9)	SPM (PPM)	T	0.1	0.023	1.6404×10^{-9}
				O	0.1	0.021	2.2692×10^{-9}
	Elements of economic Capacity (U Ec TCC) (II_3)	Tourism Economic Assessment(III_{10})	Travel Consumption (yen / day)	T	——	1.0959×10^{10}	9506.6081
				O	——	3.0025×10^{7}	6977.6104

Source: according to the statistical data of Tokyo & Osaka Metropolitan Government HP, 2009 (http://www.toukei.metro.tokyo.jp/index.htmhttp://www.pref.osaka.jp/toukei/)

Note:

T: Tokyo   O: Osaka

*. For Tokyo & Osaka, total population of each city is 12868000 & 8861602, total number of visitors is 420760000 & 143350000 respectively in 2009. The per capital amount = actual date / metropolitan daily average number of total population. This research summarizes the number of resident population and average daily visitors instead of grossing value of the city daily population. Then, the number of daily average of total population in Tokyo & Osaka is about 14020767 & 9254341 respectively in 2009.

**. In order to ensure the safe operation of power, power actual quantity plans the peak electricity consumption of the Tokyo Electric Power Company and Kansai Electric Power Company in 2009. For Tokyo & Osaka, the values are 17370000kw & 28410000kw respectively.

(1)Index weight of evaluation results

In table 5-1, II_1 for the constraint of the model, II_2 and II_3 as the object of the model, therefore, it only needs to analyze the corresponding index weight to the later two ones by FAHP method.

This study selected 5 experts (L_1~L_5) doing questionnaires, and the related algorithms are as follows (Table 5-4).

Table 5-4. Index Fuzzy Judgment Matrix of Layer II_2 & Layer 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 of layer II_2 and layer II_3 are as follows:

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

$$M^{(II)} = \begin{bmatrix} (1.920,2.600,3.240) & (1.471,1.700,2.630) \end{bmatrix}$$

By the formula (6) calculate the layer of each index comprehensive importance for layer II_2 and layer II_3.

$$M_{II_2}^{(II)} = (1.920,2.600,3.240) \otimes \left[\frac{1}{2.630+3.240}, \frac{1}{2.600+1.700}, \frac{1}{1.920+1.471} \right]$$
$$= (0.327,0.605,0.956)$$
$$M_{II_3}^{(II)} = (1.471,1.700,2.630) \otimes \left[\frac{1}{2.630+3.240}, \frac{1}{2.600+1.700}, \frac{1}{1.920+1.471} \right]$$
$$= (0.251,0.395,0.776)$$

According to the formula (7)(8)(9), get d'(II_2)=1, d'(II_3)=0.682.

According to the formula (10) (11) (12) get the weight of each index value of layer II_2 and layer II_3 as follows.

$$W^{(II)} = \begin{bmatrix} 1/(1+0.682), 0.682/(1+0.682) \end{bmatrix} = (0.595,0.405)$$

By the same way, index weight values of III_6, III_7, III_8, III_9, III_{10} are as follows.

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

Due to III_6~III_{10} are incomplete hierarchy, index weights of III_6~III_{10} can be obtained after transformation (Chen yan, 2009)[206] for:

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[206] 陈妍，李保国等. (2009). 资源与环境系统分析. 北京师大出版社, 223-224.

$$W'^{(\text{III}_6 \sim \text{III}_{10})} = (0.117, 0.120, 0.117, 0.121, 0.081)$$

After normalized:

$$W''^{(\text{III}_6 \sim \text{III}_{10})} = (0.210, 0.216, 0.211, 0.217, 0.145)$$

(2) Indexes Inspection Results

Take x as constraint number of daily visitors, d_i^+, d_i^- (i=1,2, ... , 5) indicated the positive and negative deviation variable of each target. Facilities and environmental factors belong to the same priority level. According to the formula (13) and table 5-1, a study model of UTCC Tokyo and Osaka can be established:

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

Set of constrain conditions of the general object to Tokyo and Osaka is as Table 5-5.

Table 5-5. Set of Constraint Conditions of Main Object for Tokyo & Osaka

Tokyo	Osaka
$x_1 \le 146206$	$x_2 \le 63190$
$1.2389 \cdot (x_1 + 12868000) \le 64487000$	$2.9424 \cdot (x_2 + 8861602) \le 34000000$
$0.3144 \cdot (x_1 + 12868000) \le 6859500$	$0.3653 \cdot (x_2 + 8861602) \le 5665343$
$0.4114 \cdot (x_1 + 12868000) \le 7658450$	$0.2491 \cdot (x_2 + 8861602) \le 3591055$
$8.9296 \times 10^{-5} \cdot (x_1 + 12868000) \le 5435$	$3.8782 \times 10^{-5} \cdot (x_2 + 8861602) \le 1812$
$1.4265 \times 10^{-10} \cdot (x_1 + 12868000) + d_1^- - d_1^+ = 0.04$	$5.4029 \times 10^{-10} \cdot (x_2 + 8861602) + d_1^- - d_1^+ = 0.04$
$1.4978 \times 10^{-9} \cdot (x_1 + 12868000) + d_2^- - d_2^+ = 0.04$	$2.3773 \times 10^{-9} \cdot (x_2 + 8861602) + d_2^- - d_2^+ = 0.04$
$2.1397 \times 10^{-9} \cdot (x_1 + 12868000) + d_3^- - d_3^+ = 0.06$	$3.3498 \times 10^{-9} \cdot (x_2 + 8861602) + d_3^- - d_3^+ = 0.06$
$1.6404 \times 10^{-9} \cdot (x_1 + 12868000) + d_4^- - d_4^+ = 0.1$	$2.2692 \times 10^{-9} \cdot (x_2 + 8861602) + d_4^- - d_4^+ = 0.1$
$9506.6081 \cdot (x_1 + 12868000) + d_5^- - d_5^+ = 1.0959 \times 10^{10}$	$6977.6401 \cdot (x_2 + 8861602) + d_5^- - d_5^+ = 3.0025 \times 10^{10}$
$d_i^+ \ge 0, \quad d_i^- \ge 0, \quad i = 1, 2, \cdots, 5$	$d_i^+ \ge 0, \quad d_i^- \ge 0, \quad i = 1, 2, \cdots, 5$
By lingo software solution for x1=146206，x2=63109, f=1.5890×1013.	

(3) Conclusion and Discussion

From the results we can see that the maximum values of Tokyo and Osaka are respectively 146,206 and 63,109 people/day, and the value is mainly restricted by the city housing facilities. The numbers in the model are calculated without taking into consideration of one-day touring that does not need accommodation.

From Tokyo and Osaka government statistics, in 2009, the numbers of two cities' daily visitors were 1,152,441 and 392,740 respectively. The average daily numbers of overnight visitors of the two cities are 73,890 and 30,055 respectively, and the rest are one-day trippers. From this point of view, the model value is larger than the actual value.

The example given is a time value, it calculated the data on the example in Tokyo and Osaka in 2008 January to 2012 year in Jun, and do two city model and actual values of the fitting curve, to predict the future according to the equation of a curve. As shown in Figure 5-1 and 5-2.
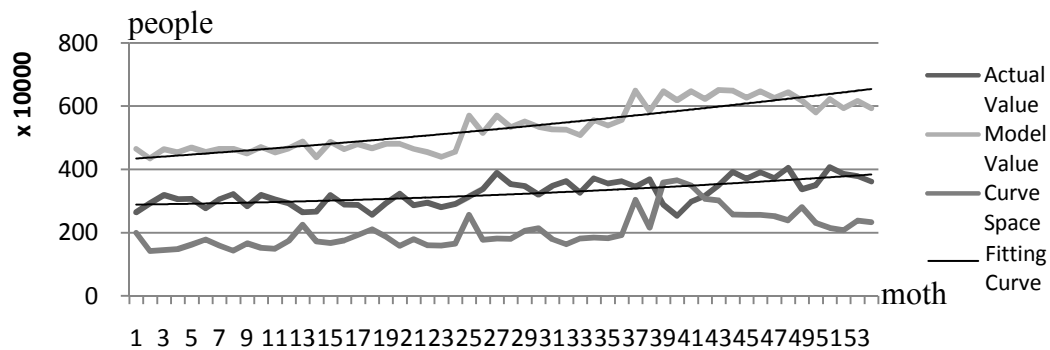

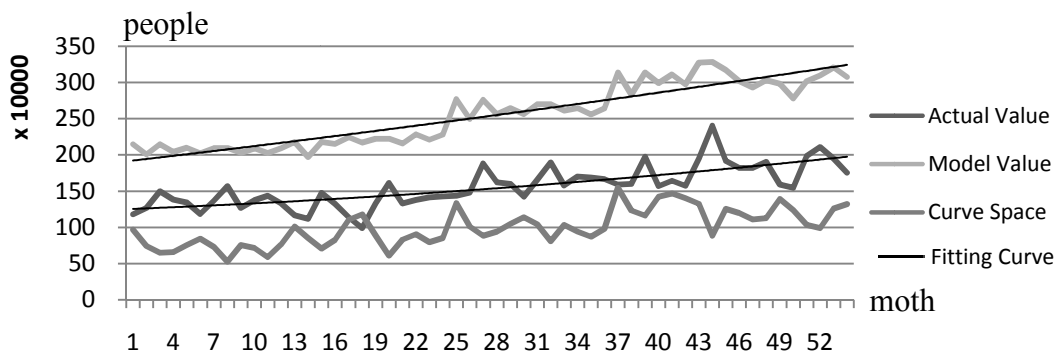**Figure 5-1. Model Value and Actual Value Curve of Tokyo Monthly from Jan.2008-Jun.2012**

Figure 5-2. Model Value and Actual Value Curve of Osaka Monthly from Jan.2008-Jun.2012

According to the judgment coefficient R^2 (Table 5-6.), curve of quadratic polynomial is selected to have regression equation.

Table 5-6. Model Value and Actual Value of Curve Fitting Equation and Related Parameters

Curve Type	Model Value Curve Fitting	Tokyo	Judgment Coefficient R^2	Actual Value Curve Fitting	Tokyo	Judgment Coefficient R^2
		Osaka			Osaka	
Linear	$y=41444x+4.2\times10^6$		0.785	$y=17917x+2.8\times10^6$		0.468
	$y=24988x+1.9\times10^6$		0.858	$y=13584x+1.2\times10^6$		0.578
Logarithm	$y=615979\ln(x)+3.5\times10^6$		0.560	$y=265104\ln(x)+2.5\times10^6$		0.331
	$y=375042\ln(x)+1.4\times10^6$		0.624	$y=201289\ln(x)+9.5\times10^5$		0.410
Exponential	$y=4.3\times10^6 e^{0.008x}$		0.794	$y=2.8\times10^6 e^{0.005x}$		0.451
	$y=1.9\times10^6 e^{0.010x}$		0.869	$y=1.2\times10^6 e^{0.009x}$		0.582
Quadratic	$y=211.7x^2+29796x+4.3\times10^6$		0.789	$y=228.4x^2+5353x+2.9\times10^6$		0.483
	$y=63.89x^2+21474x+1.9\times10^6$		0.859	$y=116.9x^2+7154x+1.2\times10^6$		0.586

Power Function	$y = 3.7 \times 10^6 x^{0.116}$	0.576	$y = 2.5 \times 10^6 x^{0.080}$	0.323
	$y = 1.6 \times 10^6 x^{0.149}$	0.646	$y = 1.0 \times 10^6 x^{0.130}$	0.420

It needs to explain that the model choice is only a partial index of the three elements from the city facilities, environment and economy as influencing factors, and other factors such as social, political, cultural and so on are not considered. Objectively speaking, these factors can have an effect on the predicted results. Therefore, in order to improve the fitting precision, this research is given up some factors that are obviously affected by non-physical elements.

From Jan.2010 to Mar.2010 period, the Japanese tourism statistical data appears a substantially change because of the influence of developing the country with tourism. In addition, during Mar.2011 to May.2011, Japan suffered from the "3.11 tsunami", and Japanese tourist market has also suffered a strong hit. The above two are clearly not in the scope of this study. Although there are other factors, but they have weaker influence compared with the above. The other factors will be further studied in the future.

Table 5-7 is obtained the fitting curve and its equation which is given up two period data from Jan.2010–Mar.2010 and Mar.2011–May.2011,

Table 5-7. Model Value and Actual Value of Curve Fitting Equation and Related Parameters for Tokyo & Osaka

Curve Type	Model Value Curve Fitting	Tokyo / Osaka	Judgment Coefficient R^2	Actual Value Curve Fitting	Tokyo / Osaka	Judgment Coefficient R^2
Linear	$y_{MVT} = 39874x + 4.2 \times 10^6$		0.807	$y_{AVT} = 20050x + 2.7 \times 10^6$		0.649
	$y_{MVO} = 24353x + 1.9 \times 10^6$		0.878	$y_{AVO} = 13592x + 1.2 \times 10^6$		0.601
Logarithm	$y_{MVT} = 582234\ln(x) + 3.5 \times 10^6$		0.557	$y_{AVT} = 293817\ln(x) + 2.4 \times 10^6$		0.451
	$y_{MVO} = 359589\ln(x) + 1.4 \times 10^6$		0.620	$y_{AVO} = 199155\ln(x) + 9.5 \times 10^5$		0.418
Exponential	$y_{MVT} = 4.3 \times 10^6 e^{0.007x}$		0.817	$y_{AVT} = 2.8 \times 10^6 e^{0.006x}$		0.636
	$y_{MVO} = 1.9 \times 10^6 e^{0.010x}$		0.891	$y_{AVO} = 1.2 \times 10^6 e^{0.009x}$		0.600
Quadratic	$y_{MVT} = 386.2x^2 + 18547x + 4.4 \times 10^6$		0.821	$y_{AVT} = 233.3x^2 + 7170x + 2.8 \times 10^6$		0.665
	$y_{MVO} = 154.6x^2 + 15819x + 1.9 \times 10^6$		0.884	$y_{AVO} = 152.0x^2 + 5199x + 1.3 \times 10^6$		0.615
Power Function	$y_{MVT} = 3.8 \times 10^6 x^{0.110}$		0.572	$y_{AVT} = 2.5 \times 10^6 x^{0.089}$		0.448
	$y_{MVO} = 1.6 \times 10^6 x^{0.143}$		0.642	$y_{AVO} = 1.0 \times 10^6 x^{0.128}$		0.424

Compared with table 5-6, decision coefficient R^2 values of table 5-7 are obviously improved, which also means that the regression equation in table 5-7 is better than that in table 5-6, meanwhile it also shows that the data given up have obvious effect

on curve fitting degree of the equation, and therefore they should be discarded. But the effect degrees have yet to be further studied.

According to the judgment coefficient R^2, the model values of fitting curve equation of Tokyo (MVT) and Osaka (MVO) are as follows.

$$y_{MVT} = 386.2x^2 + 18547x + 4.4 \times 10^6 \quad y_{MVO} = 1.9 \times 10^6 e^{0.010x}$$

The actual value of the fitting curve equation Tokyo (AVT) and Osaka (AVO) are:

$$y_{AVT} = 233.3x^2 + 7170x + 2.8 \times 10^6 \quad y_{AVO} = 152.0x^2 + 5199x + 1.3 \times 10^6$$

In order to further research, the first and the second order derivations about Tokyo and Osaka fitting curve equation of the model value are:

$$y_{MVT}' = 772.4x + 18547 \quad y_{MVO}' = 1.9 \times 10^4 e^{0.010x}$$
$$y_{MVT}'' = 772.4 \quad\quad\quad y_{MVO}'' = 1.9 \times 10^2 e^{0.010x}$$

The first and the second order derivation on Tokyo and Osaka fitting curve equation of the model value are:

$$y_{AVT}' = 466.6x + 7170 \quad y_{AVO}' = 304.0x + 5199$$
$$y_{AVT}'' = 466.6 \quad\quad\quad y_{AVO}'' = 304$$

From the first-order derivative results of regression curve of model and actual value from Tokyo and Osaka, in (0, +∞) range, we can see that two curves are alone increasing. It shows that the tourist carrying capacity in Tokyo and Osaka and the number of visitors increase with time. When two order derivation of curve of the two city model value and real value was larger than 0, the two curves in figure are concavity. The two city tourist carrying capacity and the number of visitors increase with time, which shows all incline is infinite, rather than a given value.

According to the 3rd part of chapter 4, the correlation coefficients of model value fitting curve and actual value fitting curve of Tokyo and Osaka are $r_{Tokyo}=0.838$ and $r_{Osaka}=0.844$ respectively. The coefficient values of respective correlation from the two cities are in the range of (0,1), and close to 1, and it means that the model value and true value have a very strong positive correlation in two cities. It shows that the tourist number and tourist carrying capacity have a strong positive correlation in two cities, both of which are changing with time together.

Equations and related parameters of curve spacing function d(x) are in table 5-8.

Table 5-8. Equations and Related Parameters of Curve Spacing Function d(x) of Tokyo and Osaka

Curve Type	Tokyo	Judgment Coefficient R^2	Osaka	Judgment Coefficient R^2
Linear	$y=19824x+1.5\times10^6$	0.533	$y=10761x+6.8\times10^5$	0.542
Logarithm	$y=288418\ln(x)+1.1\times10^6$	0.365	$y=160434\ln(x)+4.9\times10^5$	0.390
Exponential	$y=1.5\times10^6 e^{0.010x}$	0.571	$y=6.9\times10^5 e^{0.011x}$	0.548
Quadratic	$y=153.0x^2+11377x$ $+1.5\times10^6$	0.539	$y=2.6x^2+10619x$ $+6.8\times10^5$	0.542
Power Function	$y=1.5\times10^6 x^{0.144}$	0.401	$y=5.6\times10^5 x^{0.171}$	0.401

According to the judgment coefficient R^2, curve spacing equations of the two cities are as follows respectively.

$$d_{Tokyo}(x)=1.5\times10^6 e^{0.010x} \quad d_{Osaka}(x)=6.9\times10^5 e^{0.011x}$$

First order derivative and second order derivative of curve spacing equations respectively are as follows.

$$d_{Tokyo}'(x)=1.5\times10^4 e^{0.010x} \quad d_{Osaka}'(x)=7.6\times10^3 e^{0.011x}$$
$$d_{Tokyo}''(x)=1.5\times10^2 e^{0.010x} \quad d_{Osaka}''(x)=83\times e^{0.011x}$$

Curve equation of space function d(x) shows the difference between the model value and actual value. For the two cities, exponential equation fitting values are better than other equations. According to the characteristics of exponential function, in (0, +∞) range, the exponential function is alone increasing and tends to +∞. Difference model value function and the real value function of the two city increases with time which shows increasing trend, the reality illustrates the difference value of tourism carrying capacity and the number of visitors of the two cities and it is also increasing as the time ceaselessly.

Two reasons can explain it. One is the constantly increasing investment on the related facilities of city tourism, which results in the capacity increase of city tourism, and the increasing rate is far larger than the growth rate of tourists, which makes the both difference increase. This situation appears in the emerging tourism market (such as China). The guiding of policy to promote the investment to the construction of facilities of the city, a large number of investments makes the city tourism carrying capacity increased substantially.

The other reason is that under the condition of constant growth level in the existing carrying capacity, the speed of increase in visitors is slow, which also makes the difference value largely exchange between the two. This situation mostly appears the ripe or declining tourism market (such as Japan).The above tourism markets condition needs to be further studied.

The next is the study of the encircled area between curves, and the reference

information is in the 3rd part of chapter 4. The encircled area of curves is used to describe the difference between the total capacity number of city tourist and the total number of visitors in certain period, that is, the net capacity of city tourist in the certain time.

The enclosed area function of model and actual curves for Tokyo and Osaka are as follows.

$$S_{Tokyo}(x) = \int (d_{Tokyo}(x))dx \qquad S_{Osaka}(x) = \int (d_{Osaka}(x))dx$$
$$= \int (1.5 \times 10^6 e^{0.010x})dx \qquad = \int (6.9 \times 10^5 e^{0.011x})dx$$

In the [0, 54] range, two functions are integral respectively, and the results are as follows.

$$S_{Tokyo}(x)\Big|_0^{54} = \int_0^{54} (1.5 \times 10^6 e^{0.010x})dx \quad S_{Osaka}(x)\Big|_0^{54} = \int_0^{54} (6.9 \times 10^5 e^{0.011x})dx$$
$$= 1.5 \times 10^8 \times e^{0.01x}\Big|_0^{54} \qquad = 6.3 \times 10^7 \times e^{0.011x}\Big|_0^{54}$$
$$= 1.1 \times 10^8 \qquad = 5.1 \times 10^7$$

In a [0,54] range, the integral results of the two curves are positive, which means the model value is larger than the actual value. It shows that during the period of Jan.2008–Jun.2012, UTCCs of both cities are larger than the total number of visitors in Tokyo and Osaka. Values of the tourist capacity of two cities are 1.1×10^8 for Tokyo and 5.1×10^7 for Osaka.

According to the parameters r, d, S, k, and related data of the model we can predict the UTCC, number of visitors as well as the difference between both to city of Tokyo and Osaka in the future. This paper selects the prediction interval for Jul.2012–Dec.2013, prediction curves are as follows (Figure 5-3).
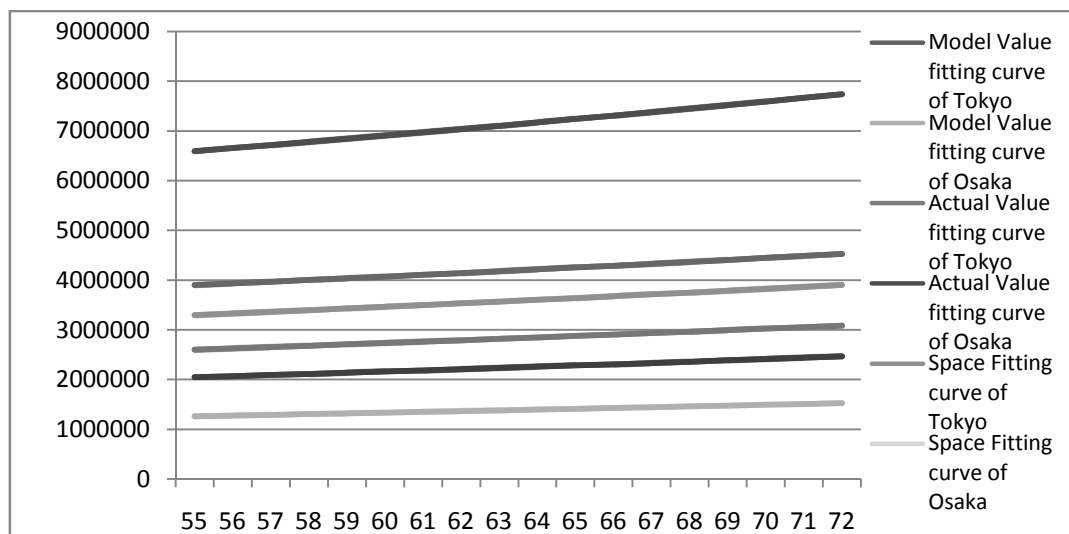
Figure 5-3. Prediction Curves of Tokyo & Osaka monthly from Jul.2012–Dec.2013

Due to the insufficient data, examples can only be based on data of Jan. 2008—Jun.

2012 to do the prediction. From the actual situation, due to the seasonal tourism activities, if we are able to analyze the same month data or the same season data with continuous long time, the effect of the curve fitting will be better.

5.3 Application Study of the Non-physical Level (Bunkyo District, Tokyo for Example)

Bunkyo District is one of Tokyo's 23 special administrative, covering 11.31km^2, with population of about 190,000 (including adults about 160,000), about 122 tourism spots and annual number of tourists of about 10,000,000 (Figure. 5-4).
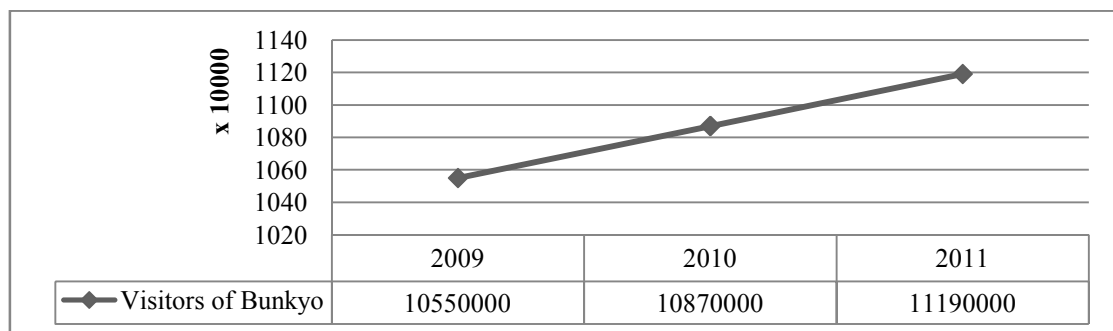
Figure 5-4. Annual Tourist Number of Bunkyo, Tokyo, 2009-2011

Source: Bunkyo District, Heisei 23-25 year, Bunkyo basic conception of execution plan, 2012 March.

(1)Stratified Random Sampling (SRS) Adopted to Determine the Sample

①To determine the number of layers.

The layer stratification is finished according to the 19 secondary administrative areas, and each layer weight is calculated with the number of population. For the pre-investigation, it is sampled according to the proportion of each layer, the sample amount is 60, and statistical data and relevant parameters are shown in Table 5-9.

Table 5-9. Bunkyo District Sampling Survey Data

Level(h)	Area	Population (N)	Layer Weight(W_h)	Layer Mean	Layer Variance (S_h^2)	Layer Standard Deviation
1	Kouraku	1,754	0.0106	0.4031	0.03712	0.19267
2	Kasuga	4,403	0.0267	0.4123	0.03424	0.18504
3	Koishikawa	16,663	0.1009	0.4326	0.03123	0.17672
4	Hakusan	14,610	0.0885	0.4432	0.03822	0.19550
5	Senngoku	13,853	0.0839	0.4453	0.03362	0.18336
6	Suido	4,455	0.0270	0.4436	0.02854	0.16894
7	Kohinata	6,016	0.0364	0.4862	0.03965	0.19912
8	Otsuka	13,837	0.0838	0.4467	0.04121	0.20300
9	Sekiguchi	4,964	0.0301	0.3925	0.03465	0.18615
10	Mejirodai	5,396	0.0327	0.3842	0.02965	0.17219
11	Otowa	4,429	0.0268	0.4765	0.02987	0.17283
12	Hongo	15,564	0.0942	0.4398	0.03624	0.19037
13	Yoshima	6,780	0.0411	0.4762	0.03162	0.17782

14	Nishikata	4,214	0.0255	0.4125	0.02763	0.16622
15	Mukogaoka	5,235	0.0317	0.3962	0.02876	0.16959
16	Yayoi	1,671	0.0101	0.3895	0.02795	0.16718
17	Nezu	5,181	0.0314	0.4136	0.03895	0.19736
18	Sendagi	16,094	0.0975	0.4437	0.04263	0.20647
19	Honkomagome	20,029	0.1213	0.4452	0.04125	0.20310
Count	——	165,148	1	——	——	——
Source: Statistic data of Tokyo						

② Determination of total sample and the sample size of each layer.

According to the formula (1), the total sample size is estimated respectively, with permissible error in 0.01~0.09, confidence to be 95%, 90% and 80% (i.e., α =0.05, α =0.1 and α=0.2). When d=0.01, α =0.05, then:

$$n = \frac{\sum_h W_h S_h^2}{\dfrac{d^2}{u_\alpha^2} + \dfrac{1}{N}\sum_h W_h S_h^2} = \frac{0.0106\times0.03712+\cdots+0.1213\times0.04125}{\dfrac{0.01^2}{1.96^2} + \dfrac{1}{165148}\times(0.0106\times0.03712+\cdots+0.1213\times0.04125)} = 1376.4$$

Similarly, the total sample n under other conditions can be obtained, at the same time, in order to ensure the convincing representation of sample to total and the accuracy of results, V (variance of overall mean estimation) and K (number of samples <2 in layers with proportional allocation method) are introduced (V≤0.001, K=0, namely the number of samples in each layer ≥2, with specific parameters shown in Table 5-10).

Table 5-10. Total Sample Amount Under Different Conditions

d	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
α=0.05	1.96	1.96	1.96	1.96	1.96	1.96	1.96	1.96	1.96
N	1376.4	346.3	154.1	86.7	55.5	38.5	28.3	21.7	17.1
V	2.60E-05	1.04E-04	2.34E-04	4.16E-04	6.51E-04	9.37E-04	1.28E-03	1.67E-03	2.11E-03
K	0	0	0	2	5	6	12	12	12
d	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
α=0.1	1.64	1.64	1.64	1.64	1.64	1.64	1.64	1.64	1.64
N	966.1	242.6	107.9	60.7	38.9	27.0	19.8	15.2	12.0
V	3.72E-05	1.49E-04	3.35E-04	5.95E-04	9.30E-04	1.34E-03	1.82E-03	2.38E-03	3.01E-03
K	0	0	0	2	6	12	12	12	12
d	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
α=0.2	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28
N	589.8	147.9	65.7	37.0	23.7	16.4	12.1	9.2	7.3
V	6.10E-05	2.44E-04	5.49E-04	9.77E-04	1.53E-03	2.20E-03	2.99E-03	3.91E-03	4.94E-03
K	0	0	2	6	12	12	12	18	19

d: permissible error   α: significant level   V: Variance of Mean Estimation   K: number of the sample in a level that smaller than 2

$V = \dfrac{1-f}{n}\sum_h W_h S_h^2$ where, $f = \dfrac{n_h}{N_h}$ n_h: sample number in the leve N_h: total number in the level

When a =0.05, d=0.07, d=0.08, d=0.09, larger error V occurs, so the total sample N corresponding to these three conditions are abandoned; at the same time, when K=0, only d=0.01, N=1376.4, d=0.02, N=364.3, d=0.03, N=154.1 meet requirements.

In a word, when α =0.05 and value constraints of N (V and K) are respectively d=0.01, N=1376.4, d=0.02, N=364.3, d=0.03, N=154.1.

Similarly, when α =0.1, the satisfying N is: d=0.01, N=966.1, d=0.02, N=242.6, d=0.03, N=107.9. When α =0.2, the satisfying N is: d=0.01, N=589.8, d=0.02, N=147.9

In this study, random sampling survey is done when d=0.03, α =0.05 N=154.1, and the sample amount of each layer is shown in Table 5-11.

Table 5-11. Sample Amount of Each Layer n_h

Level(h)	Area	Population (N)	Layer Weight(W_h)	Sample Amount (n_h)
1	Kouraku	1,754	0.0106	1.64
2	Kasuga	4,403	0.0267	4.11
3	Koishikawa	16,663	0.1009	15.54
4	Hakusan	14,610	0.0885	13.62
5	Senngoku	13,853	0.0839	12.92
6	Suido	4,455	0.0270	4.15
7	Kohinata	6,016	0.0364	5.61
8	Otsuka	13,837	0.0838	12.90
9	Sekiguchi	4,964	0.0301	4.63
10	Mejirodai	5,396	0.0327	5.03
11	Otowa	4,429	0.0268	4.13
12	Hongo	15,564	0.0942	14.51
13	Yoshima	6,780	0.0411	6.32
14	Nishikata	4,214	0.0255	3.93
15	Mukogaoka	5,235	0.0317	4.88
16	Yayoi	1,671	0.0101	1.56
17	Nezu	5,181	0.0314	4.83
18	Sendagi	16,094	0.0975	15.01
19	Honkomagome	20,029	0.1213	18.68
Count	——	165,148	1	154

(2) Indexes of FAHP

① 5 experts are invited to determine the weights of indexes via paired contrast in questionnaire. With the index II as example, judgment matrix of mean value of triangular fuzzy number is as shown in Table 5-12.

Table 5-12. Judgment Matrix of Mean Value of Triangular Fuzzy Number in Index II

		II_1	II_2	II_3	II_4	Sum of mean
Mean-value matrix of triangular fuzzy number	II_1	(1,1,1)	(0.57,0.8,1.19)	(1.06,1.35,1.68)	(1.67,1.98,2.53)	(4.3,5.13,6.4)
	II_2	(0.84,1.25,1.75)	(1,1,1)	(1.32,1.85,2.24)	(1.54,2.02,2.46)	(4.7,6.12,7.46)
	II_3	(0.59,0.74,0.94)	(0.45,0.54,0.76)	(1,1,1)	(0.94,1.32,1.72)	(2.98,3.6,4.42)
	II_4	(0.39,0.51,0.59)	(0.41,0.49,0.65)	(0.58,0.76,1.06)	(1,1,1)	(2.38,2.76,3.31)

② Non-fuzzy matrix A is obtained based on formula (9) (Table 5-13), then λ max (A) =4.0445, CR=0.017 < 0.1 obtained with formula (10), showing the original matrix pass the consistency test.

Table 5-13. Judgment Matrix of Mean Value
of Triangular non-Fuzzy Number in Index II

	II$_1$	II$_2$	II$_3$	II$_4$
II$_1$	1	0.83	1.36	2.02
II$_2$	1.27	1	1.83	2.01
II$_3$	0.75	0.56	1	1.32
II$_4$	0.5	0.51	0.78	1

③ The comprehensive importance degree of indexes II in according to formula (11),

$$S_1^{(II)}=(4.29,5.13,6.4)\otimes(\frac{1}{21.59},\frac{1}{17.61},\frac{1}{14.36})=(0.2,0.29,0.45)$$

Similarly:

$$S_2^{(II)}=(0.22,0.35,0.52)\quad S_3^{(II)}=(0.14,0.2,0.31)\quad S_4^{(II)}=(0.11,0.16,0.23)$$

④ According to the formula (12) (13), possibility that indexes II are better than other indexes.

$$P(S_1^{(II)}\geq S_3^{(II)})=P(S_1^{(II)}\geq S_4^{(II)})=P(S_2^{(II)}\geq S_1^{(II)})=P(S_2^{(II)}\geq S_3^{(II)})=P(S_2^{(II)}\geq S_4^{(II)})=P(S_3^{(II)}\geq S_4^{(II)})=1$$

$$P(S_1^{(II)}\geq S_2^{(II)})=0.802\quad P(S_3^{(II)}\geq S_1^{(II)})=0.556\quad P(S_3^{(II)}\geq S_2^{(II)})=0.387$$
$$P(S_4^{(II)}\geq S_1^{(II)})=0.190\quad P(S_4^{(II)}\geq S_2^{(II)})=0.063\quad P(S_4^{(II)}\geq S_3^{(II)})=0.659$$

According to formula (14), each index weight vector is got:

$$d'(B_1^{(II)})=P(S_1^{(II)}\geq S_2^{(II)},S_3^{(II)},S_4^{(II)})=\min(0.802,1,1)=0.802$$

Similarly,

$$d'(B_2^{(II)})=1\quad d'(B_3^{(II)})=0.387\quad d'(B_4^{(II)})=0.063$$

The weight vector of index II can be expressed according to formula (15):

$$W'=(d'(B_1^{(II)}),d'(B_2^{(II)}),\cdots,d'(B_n^{(II)}))^T=(0.802,1,0.387,0.063)^T$$

According to the formula (16) (17), normalized weights value of index II is:

$$W=(\frac{0.802}{2.252},\frac{1}{2.252},\frac{0.387}{2.252},\frac{0.063}{2.252})^T=(0.356,0.444,0.172,0.028)$$

Similarly, weights value of index III can be obtained (and in this study, indexes III shows non-fully hierarchical structure, and the transform shall refer to [26] in reference), and when they are calculated with indexes II, comprehensive weight values of indexes III are obtained (Table 5-14).

Table 5-14. Weight Value of Indexes III (unit: %)

Index	III$_1$	III$_2$	III$_3$	III$_4$	III$_5$	III$_6$	III$_7$	III$_8$	III$_9$	III$_{10}$	III$_{11}$	III$_{12}$	III$_{13}$	III$_{14}$
Weight	7.75	6.72	6.75	7.31	7.08	12.7	10.4	11.8	9.5	5.23	5.71	6.28	1.58	1.25

⑤ Evaluation index value

The residents in Tokyo Bunkyo District are the research objects from 2012 October to 2012 December), via interview and questionnaire. 154 samples are obtained in public places (citizen hall, park, ward, associations and so on) with stratified random sampling; according to Table 4-1 and fuzzy arithmetic formula (2) (4), mean value of triangular fuzzy number of indexes III are shown in Table 5-15.

Table 5-15. Mean Value of Triangular Fuzzy Number of Indexes III

Index	III$_1$	III$_2$	III$_3$	III$_4$	III$_5$	III$_6$
Value	(0.23,0.37,0.51)	(0.51,0.63,0.72)	(0.32,0.44,0.53)	(0.51,0.69,0.81)	(0.45,0.67,0.77)	(0.19,0.38,0.55)
Index	III$_7$	III$_8$	III$_9$	III$_{10}$	III$_{11}$	III$_{12}$
Value	(0.48,0.61,0.73)	(0.43,0.58,0.72)	(0.42,0.54,0.67)	(0.52,0.64,0.78)	(0.56,0.68,0.82)	(0.41,0.53,0.68)
Index	III$_{13}$	III$_{14}$				
Value	(0.63,0.72,0.89)	(0.62,0.71,0.87)				

According to table 5-9, table 5-10 and formula (18), the comprehensive evaluation value of tourism in Bunkyo District on the social psychology of the residents is:

$$Q_{\mathrm{I}} = \sum_{i=1}^{14} x_i^{(\mathrm{III})} \otimes d(\mathrm{B}_i^{(\mathrm{III})})$$
$$= 0.0775 \times (0.23,0.37,0.51) + 0.0672 \times (0.51,0.63,0.72)$$
$$+ \cdots + 0.0125 \times (0.62,0.71,0.87)$$
$$= (0.41,0.56,0.69)$$

The language value variables in Table 4-1 show that the comprehensive effects of tourism on the social psychology of Bunkyo District residents tend to be positive.

Indexes II can be further investigated to analyze impact extent and effect of the 4 aspects.

The impact extent of the 4 indexes in layer II can be compared after that the fuzzy comprehensive evaluation values are transferred into non-fuzzy number specifically as follows.

$$Q_{\mathrm{II}_1} = \sum_{i=1}^{5} x_i^{(\mathrm{III})} \otimes d(\mathrm{B}_i^{(\mathrm{III})})$$
$$= 0.0775 \times (0.23,0.37,0.51) + 0.0672 \times (0.51,0.63,0.72) + 0.0675 \times (0.32,0.44,0.53)$$
$$+ 0.0731 \times (0.51,0.69,0.81) + 0.0708 \times (0.45,0.67,0.77)$$
$$= (0.14,0.2,0.24)$$

Similarly,

$$Q_{\mathrm{II}_2} = (0.16,0.23,0.29) \quad Q_{\mathrm{II}_3} = (0.08,0.11,0.13) \quad Q_{\mathrm{II}_4} = (0.018,0.02,0.025)$$

They are transferred into non-fuzzy numbers according to formula (10):

Q_{II_1}=0.196 Q_{II_2}=0.231 Q_{II_3}=0.106 Q_{II_4}=0.021

Investigation on social psychology of Bunkyo District residents shows that, impact extent of indexes II evaluation value on the total target are social, ecological, facilities and others in sequence from large to small.

The effect of indexes II can refer to "no effect (0.25, 0.5, 0.75) (with corresponding non-fuzzy number 0.5)" in language value variables, the results of paired comparison are as follows:

Q_{II_1}=(0.405,0.56,0.668) Q_{II_2}=(0.38,0.528,0.668) Q_{II_3}=(0.497,0.617,0.76) Q_{II_4}=(0.625,0.715,0.88)

The corresponding non triangular fuzzy numbers are respectively:

Q_{II_1}=0.552 Q_{II_2}=0.526 Q_{II_3}=0.621 Q_{II_4}=0.728

It is shown that the comprehensive evaluation of indexes II tend to positively impact social psychology to residents, with II$_3$ and II$_4$ to be obvious, II$_1$ and II$_2$ to be non-obvious.

Results and Discussions

Based on review of literatures about the social psychological carrying capacity of residents in tourism destinations, this study establishes the evaluation index system of social psychological carrying capacity of residents in tourism destinations.

Analysis model is established with FAHP, the mass psychological investigation and the quantitative investigation are combined, leading to objective comprehensive evaluation results. The empirical study on social psychological carrying capacity of residents in Tokyo Bunkyo District on tourism activities is carried out, leading to the following 3 conclusions:

①Generally, the comprehensive social psychological carrying capacity of residents in Tokyo Bunkyo District tends to be positive on tourism activities.

The evaluation of Q$_I$ show that the local residents tend to be slightly support development of tourism, which is correlated with Japan's actual national conditions and its culture. Japanese society has kept stable over many years, with little radical change and large development activities, thus people's ideology tends to be stable, with no exception of Bunkyo District whose residents are unlikely to have obvious special social psychological fluctuations. In addition, "introverted characteristic" promoted by Japanese culture also affect it.

Compared to Chinese, European and Americans, Japanese are more moderate, and their "introverted characteristic" stops them from expressing their willingness, thus further researches are needed.

②The development of tourism has drawn positive effect on most indexes.

The survey finds that, regional awareness, policy support, the number of tourist facilities, infrastructure, the degree of social civilization, vegetation, water and air quality indexes can have obvious positive effect (displaying mean value of non-fuzzy evaluation of more than 0.6) and mean value of non-fuzzy evaluation of the 2 indexes positive (regional awareness, policy support) with the highest value of positive impact are more than 0.7, which proves the popular saying that "tourism is the city's best business card".

Compared with other methods, the development of tourism can bring more geographical widespread popularity, thus Bunkyo District residents are also willing to welcome more visitors in the future.

In addition, it is also found that tourism development not only causes no damage to the ecological environment (except for garbage and wild animal index), but promotes the investment from local government and the public into environmental protection, thus the overall environment is better than before, which also, from the angle of tourism, supports the extended theory of "broken window effect"; that is, if clean environment is created, no unhealthy phenomenon is indulged, others will follow this manner to enhance the overall effect.

Therefore, the development of tourism can benign interaction with environmental protection and be recognized by the public, and this recognition can be constantly learned and strengthened in the group, which can be seen from the residents' evaluation of social civilization. The majority of respondents believe that the development of tourism can better their civilization.

The tourism facilities and infrastructure establishment also positively correspond to the development of tourism which promotes the development of local infrastructure and tourism facilities such as increase of catering and entertainment, thus the residents welcome tourists.

③The results of most investigated indexes show residents' dislike of visitors (with mean of non-fuzzy numbers evaluation below 0.4), with garbage in tourism site in ecological environment elements and order in social elements as representatives showing the residents' negative evaluation.

These two aspects are inevitable problems following the development of tourism in most regions. Different tourists hold different environmental protection consciousness, and the influx of immigrants can also cause social problems such as security decline.

The evaluation indexes demonstrate that the residents in Bunkyo District are against the two aspects. Most questionnaires reflect that local area witnesses more and more waste, social security events, especially small civil cases and disputes with the development of tourism industry, which also shows that the residents' life is directly and indirectly intervened.

④Evaluation of some indexes shows no strong unwillingness (with mean of non-fuzzy numbers evaluation in 0.4~0.6), including impact on wild animal in environmental factors, impact on traditional culture and personal beliefs in social

elements and feeling toward concentration of public facilities all of which are around 0.5, indicating that tourism development causes no particularly strong fluctuations.

Evaluation of impact on wild animal tends to be negative, but it is difficult to be eliminated, since the increase of human activities is bound to impact on local wild animal habitat, leading to reduction in species and quantity of original wild animals; however, this seems to be not the local residents' reasons to restrict or disagree of tourism development.

Evaluation results of traditional culture and the resident belief tend to be slight positive, which demonstrate that visitors draw some impact on local traditional culture and personal beliefs, but this is understood by the majority, leading to no serious opposition and conflict due to different religions and beliefs.

Evaluation of the concentration degree of public facilities shows almost no impact, which is determined by stable development of society. Japanese economy experienced much rapid development in 1960s-1980s, then slipped severely after the economic bubble burst, but now it still helps to maintain high-level social development to be an economic power, however, few city expansion, construction and other rare large-scale development changes take place.

Therefore, the local development in various aspects has kept for a long period of time, so the public has no obvious cautiousness for the tourists, therefore, the evaluation deviates little from 0.5.

5.4 Reflection on Integration of Results of Quantitative Research and Qualitative Research

According to Chapter Four, quantitative research is integrated into qualitative research with Bunkyo District as an example.

(I) Whether to modify?

Yes.

(II) Reasons for adjustment?

The results of investigation of Bunkyo District residents in 5.3 show that they welcome tourists, therefore, according to their attitude and the actual conditions, they will accept more travelers in the future. We can predict that, the carrying capacity of physical indexes in the near future time will be greater than the current value.

(III) Adjustment degree?

No popular method has been formulated by scholars to modify quantitative research results by qualitative research, so mostly decision-maker's (groups) experience is taken as the standard, so this study proposes a method for reference only.

Some data of key index with district as unit from governments cannot be obtained, so

it is difficult to study directly the physical dimensions of Bunkyo District, and only experience can be relied on. According to the investigation results of Tokyo and Osaka UTCC at physical dimensions in 5.2, the main determinant is city hotel.

Therefore, Bunkyo UTCC at physical dimensions is represented by the number of hotel beds (Table 5-16).

Table 5-16. Hotels and Guest Number of Bunkyo District, Tokyo

No.	Hotel Name	Capacity (people)	Address
1	ホテルサトー 東京	122	1-4-4, Hongo, Bunkyo-ku, Tokyo
2	ホテルウィングインターナショナル後楽園	116	1-25-11, Hongo, Bunkyo-ku, Tokyo
3	お茶の水イン	118	1-3-7, Yushima, Bunkyo-ku, Tokyo
4	ホテルリブマックス後楽園	52	3-1-2, Koishikawa, Bunkyo-ku, Tokyo
5	東横イン後楽園文京区役所前	186	2-2-11, Koishikawa, Bunkyo-ku, Tokyo
6	水道橋グランドホテル	274	1-33-2, Hongo, Bunkyo-ku, Tokyo
7	ドーミーイン水道橋	121	1-25-27, Hongo, Bunkyo-ku, Tokyo
8	東京グリーンホテル後楽園	152	1-1-3, Kouraku, Bunkyo-ku, Tokyo
9	フォーレスト本郷	73	6-16-4, Hongo, Bunkyo-ku, Tokyo
10	後楽賓館（後楽ガーデンホテル）	171	1-5-3, Kouraku, Bunkyo-ku, Tokyo
11	お茶の水セントヒルズホテル	184	2-1-19, Yushima, Bunkyo-ku, Tokyo
12	東京ガーデンパレス	271	1-7-5, Yushima, Bunkyo-ku, Tokyo
13	ホテル　リンデン	71	3-5-10, Yushima, Bunkyo-ku, Tokyo
14	太栄館	200	6-10-12, Hongo, Bunkyo-ku, Tokyo
15	フォーシーズンズホテル椿山荘　東京	518	2-10-8, Sekiguchi, Bunkyo-ku, Tokyo
16	東京ドームホテル	2230	1-3-61, Kouraku, Bunkyo-ku, Tokyo
17	ホテル機山館	207	4-37-20, Hongo, Bunkyo-ku, Tokyo
18	鳳明館森川別館	66	6-23-5, Hongo, Bunkyo-ku, Tokyo
19	カプセルランド湯島	112	3-36-6, Yushima, Bunkyo-ku, Tokyo
20	鳳明館本館・台町別館	390	5-10-5, Hongo, Bunkyo-ku, Tokyo
21	ホテルウィング インターナショナル後楽園	127	1-25-11, Hongo, Bunkyo-ku, Tokyo
22	朝陽館本家	240	1-28-5, Hongo, Bunkyo-ku, Tokyo
23	ホテル江戸屋	100	3-20-3, Yushima, Bunkyo-ku, Tokyo
24	楽楽の湯　ドーミーイン水道橋	148	1-25-27, Hongo, Bunkyo-ku, Tokyo
	Count	6249	
Calculation of the guest number: Single room: 1 people / room Standard room and double room: 2 people / room Suite: 2 people / room Other (Japanese-style): 4 people / room			

Table 5-16 shows that Bunkyo District's hotel 6,249 people/ day (Table 5), namely 187,470 people / month, 2,280,885 people / year.

The number of visitors living in Bunkyo District hotels is calculated as follows:

Simulation equation of monthly carrying capacity model value:

$$y_{MVT} = 386.2x^2 + 18547x + 4.4 \times 10^6$$

Table 5-16 displays that Bunkyo physical carrying capacity is about 4.27% of Tokyo's (146,206 people/ day), so fitting equation of Bunkyo monthly physical carrying capacity will be:

$$y_{MVB} = 16.5x^2 + 792.7x + 188056$$

2012 Tokyo hotel occupancy rate was 54.5%[207], accordingly, fitting equation of number of tourists demanding accommodation in Bunkyo District in 2012 is:

$$y_{MVB} = 9.0x^2 + 432.0x + 102490$$

Based on Bunkyo District physical carrying capacity and actual number of visitors demanding accommodation, data of Bunkyo District for the next 6 months are shown in Figure 5-5.

x 10000	1	2	3	4	5	6
UTCC of Bunkyo	187470	187470	187470	187470	187470	187470
Actual Value	102931	103390	103867	104362	104875	105406
Difference	84539	84080	83603	83108	82595	82064
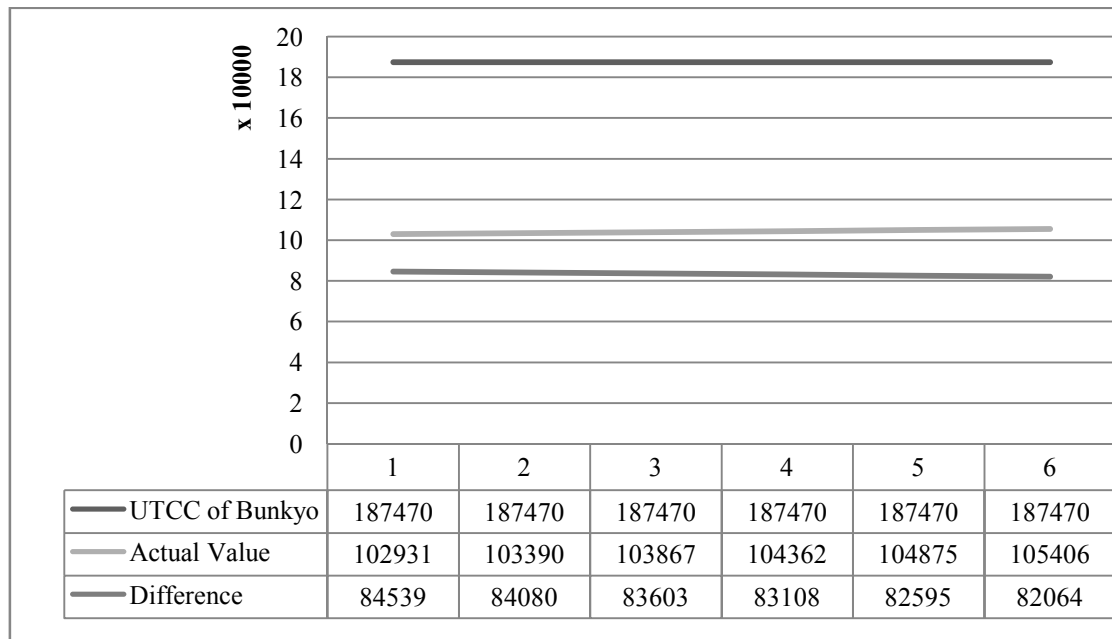
Figure 5-5. Physical Carrying Capacity of Bunkyo District (visitor), 2013.1-2013.6

The data shows that Bunkyo physical carrying capacity keeps constant, but the number of visitors is increasing, and the difference between the two gradually reduces. According to the survey of Bunkyo District residents' willingness in 5.3, when the existing number of tourists keeps constant, Bunkyo District residents welcome visitors in the future, therefore their carrying capacity will also increase. Based on the existing situation, it is inappropriate to keep 187,407 people/ month which need to be modified.

The correction method employed in this study refers to simulation equation of Tokyo monthly carrying capacity model, fitting Bunkyo monthly capacity curve, as is shown in Figure 5-6.

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[207] Japan Tourism Agency, Ministry of Land, Transport and Tourism. (2013). *Statistics and Surveys of Tourism Industry*.

	1	2	3	4	5	6
Modified	188865	189707	190583	191491	192432	193406
UTCC of Bunkyo	187470	187470	187470	187470	187470	187470
Actual Value	102931	103390	103867	104362	104875	105406
M - A	85934	86317	86716	87129	87557	88000
UTCC - A	84539	84080	83603	83108	82595	82064
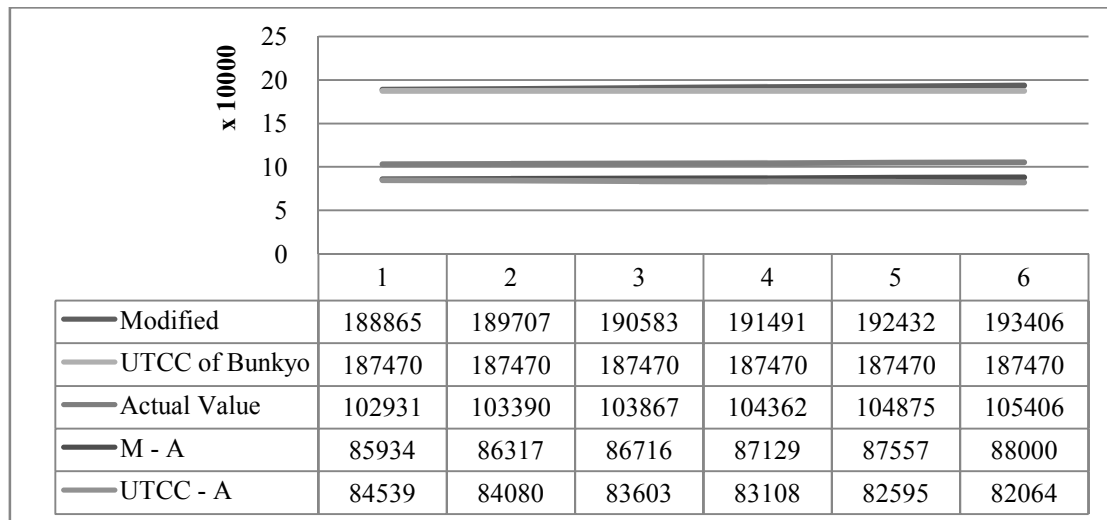
Figure 5-6. Modified UTCC of Bunkyo District

In Figure 5-6, the difference between modified curve and that of the original carrying capacity is considered as the corrected value of Bunkyo physical social carrying capacity. Difference of the modified value and the actual value is rising up along with the social-psychological carrying capacity which was evaluated in 5.3 of Chapter 5, which was considered appropriate.

It shall be noticed that tourism carrying capacity is related with many factors, the study on physical or non-physical tourism carrying capacity is just a research ideology and trial algorithm. Some indexes are divided in detail, so as to do algorithm case studies to show specific explanation to assist to understand the research ideology.

Reality is much more complex, UTCC is influenced by more influential and decisive factors. Different research perspectives shall consider different influencing factors and different index system, including accommodation, water supply, power supply and other facilities, as well as transportation, natural disasters, political factors. Therefore, research ideology is somehow more important than the research method.

Chapter 6

SUMMARY, FINDINGS, CONCLUSIONS, IMPLICATIONS, AND RECOMMENDATIONS

6.1 Summary

This paper focuses on the following three parts:

(1) The necessity of research on UTCC, the background and purpose are analyzed, accordingly, it is proposed that the research on UTCC means a research direction based on practical needs and development of subject, and it is inevitable in urbanization process.

(2) The literatures about carrying capacity are reviewed from ecology, sociology, economics and political science, based on which the connotation of UTCC is analyzed, then the elements influencing UTCC are summarized from facilities and ecological, social and cultural, political and economic aspects, and all their connotations are defined and clarified.

(3) According to the influencing elements, physical and non-physical evaluation index systems of UTCC are established, and investigation models of the above systems are constructed according to their different attributes followed by research on application.

6.2 Findings & Conclusions

According to the above research findings:

1. Theoretically, UTCC is the product of deepening development of tourism theory.

Research on UTCC is the extension of research on carrying capacity with cities as objects. In 1970s, the scholars have realized the necessity to research the excessive use of resources due to regional population scale agglomeration in short time, but relevant case studies did not arise until in early 1990s in Europe and the United States, and few have been raised in Asian countries.

UTCC is produced with the accelerated urbanization process. The speed-up urbanization raises a large number of city residents' concentrated demand of travel (rest) in a short period of time (such as vacations), leading to large-scale population distribution in short time, followed by malignant utilization of tangible and intangible city resources, so that the balance of the original city system is unfortunately destroyed.

The resources associated with tourism in a city can be divided into two categories, tangible one and intangible one.

UTCC aims to work out the number of visitors a city can hold constrained by the two kinds of resources. Therefore, the carrying capacity of different resources shall be made

clear. But the existing researches on carrying capacity mainly focus on partial physical resources with quantitative methods, which is unconvincing for research of UTCC influenced by many factors.

Modern theories of carrying capacity have been married with sociology, economics, ecology, environmental science, political science, management science, computer application and others, therefore, comprehensive researches with multiple-perspectives and multi-methods are necessary. Therefore, it will be the tendency to integrate research on carrying capacity into the disciplines, which also conforms to practical needs.

2. Practically, the research on carrying capacity shall adapt to the development of modern society.

City is a special open social system, and traditional research on carrying capacity of environment fails to meet the needs of modern city development, so the traditional evaluation ideology and methods should tend to be consistent with the development of modern city.

Industrialization has accelerated the urbanization process of human society, while informationization has accelerated the process of globalization. With the increasing regional concentration of human society, the problems about carrying capacity arise, including that of resources and social psychological one, as well as UTCC.

The logical reasoning process in research on UTCC is important. This study is based on the existing research results embracing independent perspectives and takes comprehensive evaluation perspective, refers to various methods and disciplines and adopts qualitative and quantitative analysis to reveal UTCC level from more comprehensive and objective perspectives, facilitating decision-making. Moreover, cross-cultural, cross-regional comparative studies on UTCC are required, to revise and perfect the UTCC model and enhance science and adaptability of evaluation of UTCC.

Development of modern society raises the need to adopt various techniques to study UTCC, and GIS, GPS, RS, VR and other advanced technologies allow more accurate and intuitive study on UTCC (Fig 6-1. to Fig 6-4.).

Development of modern science provides more diverse tools to study UTCC, from mathematics to computer application all of which are combined to comprehensively and objectively reveal the objective laws. The better application of emerging technology is the direction of tourism development and the target of technology combined with practice.

With the popularization and application of intelligent terminals (PC and intelligent mobile phones), research on carrying capacity can be much improved For example, in the past, only with professional instrument can the GPS information of researched object be obtained, but now many APP software can help to easily get the information, which create powerful practical development direction for study on carrying capacity and offer quite a little of real-time accurate information of sample, so it can be expected the researches on carrying capacity embracing advanced technologies will, in the near future, be more close to the ordinary people.
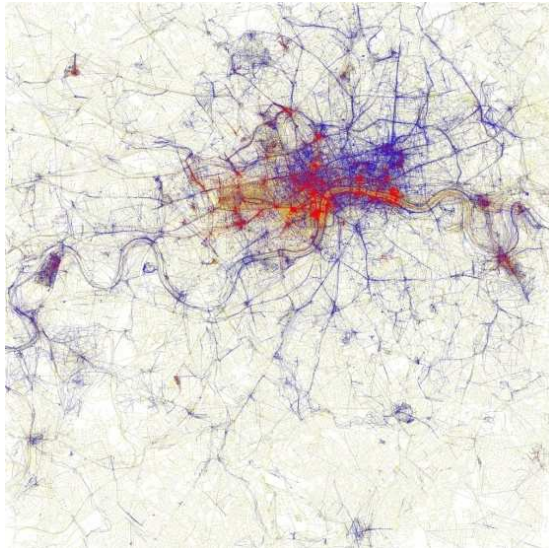
Fig 6-1. Distribution of the Tourist and Locals by Geotagged Photographs, London
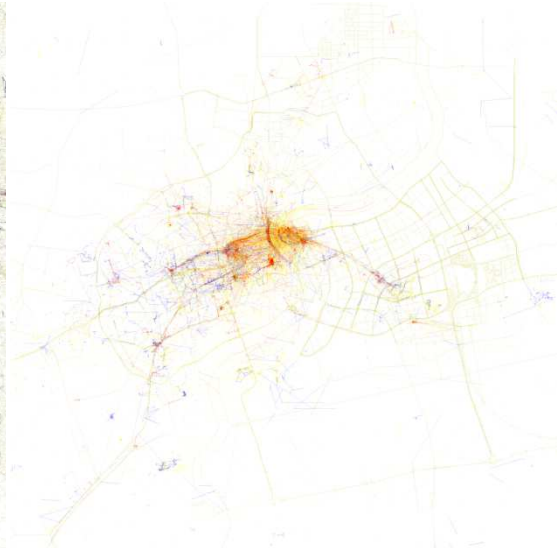
Fig 6-2. Distribution of the Tourist and Locals by Geotagged Photographs, Shanghai
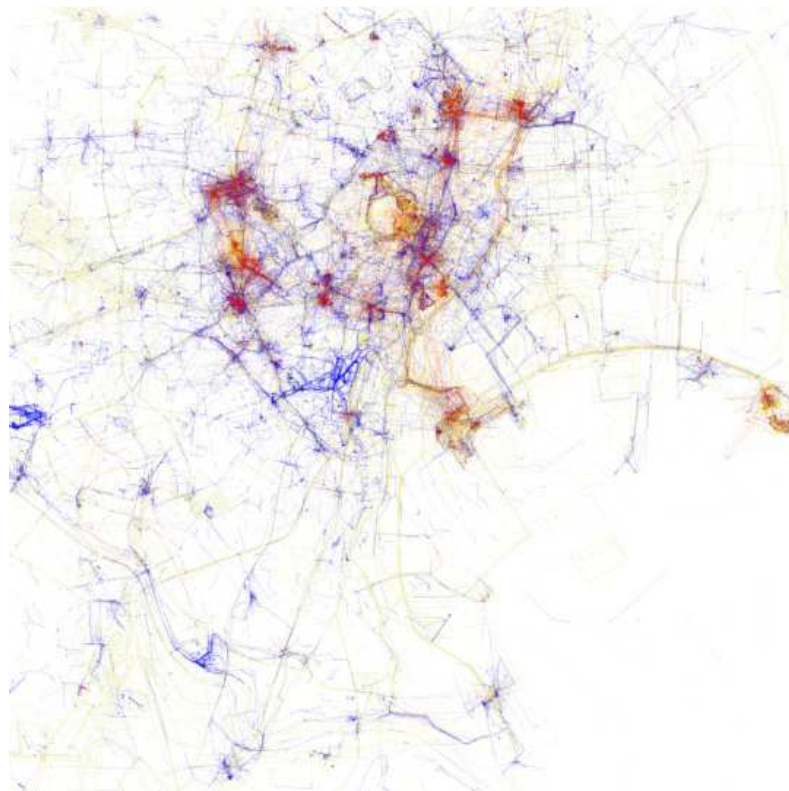
Fig 6-3. Distribution of the Tourist and Locals by Geotagged Photographs, Tokyo

Source: Figure 6-1, figure 6-2, and figure 6-3 are all from the website of http://www.flickr.com/photos/walkingsf/sets/72157624209158632/ by Eric Fischer.

Figure 6-1 to figure 6-3 shows the distribution of the tourist by geotagged photographs which were taken by the two groups.

Geotaggered photos are made by GIS (Geographic Information System) software with GPS (Global Positioning System) information of the photographs from the website of http://www.flickr.com.

GIS is a system designed to capture, store, manipulate, analyze, manage, and present all types of geographical data. The acronym GIS is sometimes used for geographical information science or geospatial information studies to refer to the academic discipline or career of working with geographic information systems (Kenneth et al., 1995)[208].

GIS technology was firstly used for the distribution of cholera led to the source of the disease by John Snow in 1854 (John et al., 1854)[209]. He depicted a cholera outbreak in London using points to represent the locations of some individual cases, possibly the earliest use of a geographic methodology in epidemiology.

With the development of the computer science, modern GIS technologies have combined with digital information and various digitized data creation methods are used. The most common method of data creation is digitization, where a hard copy map or survey plan is transferred into a digital medium through the use of a CAD program, and geo-referencing capabilities.

In this case, the colorful point represents different locations of the photo taken by different people such as the locals, tourists, etc. GPS information of the photographs is represented on the map by GIS software.

Photos are distinguished as the locations of different photographers by some restrictions so as to describe the distribution of locals and tourists. In this case, restriction is the interval of the photo taken.

In these three figures, blue points on the map are pictures taken by locals (people who have taken pictures in this city dated over a range of a month or more).

Red points are pictures taken by tourists (people who seem to be a local of a different city and who took pictures in this city for less than a month).

Yellow points are pictures where it can't be determined whether or not the photographer was a tourist (because they haven't taken pictures anywhere for over a month). They are probably tourists but might just not post many pictures at all.

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[208] Kenneth, E. F., Margaret L. (1995) Geographic Information Systems as an Integrating Technology: Context, Concepts, and Definitions. [online] University of Texas at Austin,
http://www.colorado.edu/geography/gcraft/notes/intro.html
[209] John S., Stamp, L. D. (1964). A Map of Cholera Death in London, 1840s. [online]
http://www.york.ac.uk/depts/maths/histstat/snow_map.htm

Fig 6-4. Virtual Urban by VR Technology

Fig 6-5. Tourists' Carrying Capacity of Buildings in Virtual Parks by VR Technology (1)

Fig 6-6. Vehicle and Tourists' Carrying Capacity of Buildings in Virtual Parks by VR Technology (2)

Source: Figure 6-4, figure 6-5, figure 6-6 are all from the website of http://www.geoville.com/index.php/virtual-citys.html

VR (Virtual Reality) technology applies to computer-simulated environments that can simulate physical presence in places in the real world, as well as in imaginary worlds.

VR technologies can be used to simulate the real world so as to study the carrying capacity of the urban. With individual data of people, resource, building, transportation etc., the capacity of the city can be studied in imaginary world by VR technology.

Figure 6-4, figure 6-5, and figure 6-6 describes the situation of the buildings, transportation, tourists in some areas (such as the park) in a virtual urban by VR technology. It can be seen the urban elements such as the roads, buildings, stadiums even tourists and citizens can be reflected and simulated clearly from the pictures showed above.

UTCC research, a complex system affected by many factors, needs a variety of methods and perspectives for evaluation. UTCC not only reflects the accommodated tourists at physical level, but also depends on city cultures, city mental capacity at all levels, urban tourism type, city layout, efficiency of the system and other multiple factors. So many factors are influencing the UTCC that the studies can get the comprehensive evaluation results only from the global perspective.

Overall evaluation will inevitably involve specific investigation of each aspect with proper method determined by different professions, characteristics and properties. Therefore, the results of research on carrying capacity obtained from different methods shall be further studied and evaluated with comprehensive perspectives, which is one of the research emphasis and difficulties. This study gives an approach to deep thinking and a corresponding method, but further reflection is also needed.

6.3 Recommendations

This study established a preliminary study model either from a qualitative or a quantitative point of view both provide an inclusive platform for the study of UTCC. However, there still are the following problems needed to be further studied:

1. Appropriate range of carrying capacity shall be defined. It does not mean that UTCC can be unlimitedly bigger. The large gap between UTCC and the number of visitors also means that the resources are far from being fully utilized, leading to certain "waste".

In addition, under some conditions, physical elements may allow quite a number of visitors, but factors at non-physical level may lead to spiritual rejection between individuals. Therefore, how to define suitable range of carrying capacity to guide the urban tourism development needs thinking about.

2. The mutual influences of different elements and their impact on models still need further study. The tourism industry is much comprehensive, including providing both tangible products and intangible service; at the same time, both tourists and residents are influenced by tangible and intangible factors which also embrace interactions.

Good policy for travel may attract large-scale tourists, so that local tourism practitioners will benefit while followed by some other negative social problems, thereby affecting local tourism carrying capacity. The relationships between different factors and their effect on the model results still need further focus.

3. The non-physical elements (such as social capacity and political capacity of urban tourism), including its own content and its research methods, need further study. Elements of physical level can usually be inspected by tangible media, while study on non-physical factors is difficult, so different investigation methods are required to work out their influence on UTCC, therefore, further research shall be done.

4. Mathematical method shall be better combined with computer application. With the development of mathematics and computer application, study on carrying capacity is facing more diverse and flexible research methods and perspectives, which is the result to combine with the reality of social development.

Various factors involved in carrying capacity have their own professional and academic backgrounds, a variety of tools can objectively reflect the nature of elements of carrying capacity; what's more, various computer application tools and software promote the research on carrying capacity to be practical.

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Appendices

Appendix A: Introduction of the Component Study Survey

The survey conducted is to regarding the influence to the citizens by tourists who came to Bunkyo, Tokyo.

The survey was taken in Bunkyo area by Stratified Random Sampling (SRS) method during Jan. and Feb., 2013. 157 valid replies were obtained from the citizens of the civic groups and organizations such as Japanese-Language Classes, City Tourism Association, Academy Support of Lifelong Learning and so on in Bunkyo.
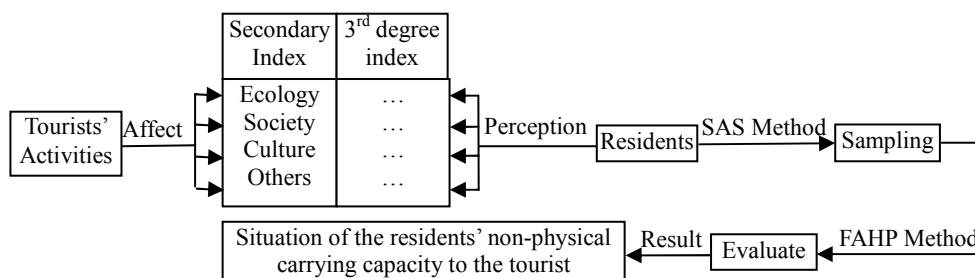

Fig. 1 Research Thinking

Figure 1 shows the research thinking of the component survey study. The activities of the tourists would probably impact the daily life of the residents from aspect of politic, economy, culture, society and so on. So by detecting the attitude to the influence of the tourists, it can be found the tolerance degree of the resident which is the very capacity we are looking for – nonphysical carrying capacity.

It should be declared that there are kinds of nonphysical carrying capacity by different subjects – the resident, the tourist, the employee and others. In this research, we only study the resident's capacity.

Appendix B: Questionnaire

Questionnaire of the Soft Environment of Tokyo Tourism Carrying Capacity
(For Residents)

Dear Sir/Madam:
We are conducting an academic survey regarding the influence of the tourists to the citizens of Bunkyo. Please indicate the level of influence of each statement according to your real perception.

According to the data from the statistic department of Bunkyo (Fig. 2), there are about 122 tourism spots including 43 temples and Shinto shrines, 51 parks and gardens in Bunkyo area. Tourist number is more than 100, 000, 00 people per year.
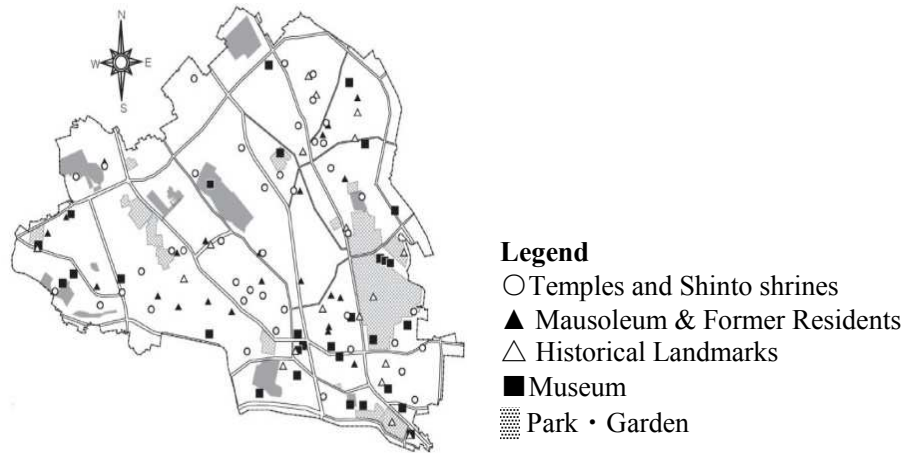
Fig. 2 Tourism Spots in Bunkyo

Legend
○ Temples and Shinto shrines
▲ Mausoleum & Former Residents
△ Historical Landmarks
■ Museum
▨ Park・Garden

Your comment is highly important to this academic survey research. The survey data will be treated with anonymity and confidentiality. Therefore, please feel ease on the answer of questionnaire.

Thank you very much for your assistance.

Fujii Research Lab
Department of Regional Development
Toyo University
Zhang Bo, Doctor Course

1. Questionnaire

Question A-1 About the **social environment** of Bunkyo, how the following items do you feel are woven. Please tick the appropriate box below.

1. **Bunkyo area has a high profile.**

   □ Completely Agree
   □ Agree
   □ I don't know
   □ Disagree
   □ Completely Disagree

2. **In order to raise the profile of Bunkyo, I hope there will be more tourists visit this area in the future.**

   □ Completely Agree
   □ Agree
   □ I don't know
   □ Disagree
   □ Completely Disagree

3. **In order to increase the opportunities to communicate among residents, it is necessary to organize more gatherings by associations such as NPO and so on.**

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□ Completely Agree
□ Agree
□ I don't know
□ Disagree
□ Completely Disagree

4. **Compared with the previous, number of tourist and the opportunity to interact with them has been increased.**

□ Completely Agree
□ Agree
□ I don't know
□ Disagree
□ Completely Disagree

5. **I fell exciting when tourists share their unusual experience with me, and I eager for more opportunities like that.**

□ Completely Agree
□ Agree
□ I don't know
□ Disagree
□ Completely Disagree

6. **The environmental awareness of Bunkyo residents has been improved due to the development of tourism than before.**

□ Completely Agree
□ Agree
□ I don't know
□ Disagree
□ Completely Disagree

7. **In order to improve residents' environmental awareness, I hope there will be more tourists visit Bunkyo area in the future.**

□ Completely Agree
□ Agree
□ I don't know
□ Disagree
□ Completely Disagree

8. **The manner of local residents has been improved due to the development of tourism.**

□ Completely Agree
□ Agree
□ I don't know
□ Disagree

□ Completely Disagree

9. **With the increase in the number of tourists, residents' daily life has been affected by tourists' noise.**

    □ Completely Agree
    □ Agree
    □ I don't know
    □ Disagree
    □ Completely Disagree

10. **The traditional culture (food culture, wine culture and so on) and custom of Bunkyo area have been changed due to the increase of the tourist.**

    □ Completely Agree
    □ Agree
    □ I don't know
    □ Disagree
    □ Completely Disagree

11. **Lifestyle and religion of the tourist have an effect on daily life of the residents.**

    □ Completely Agree
    □ Agree
    □ I don't know
    □ Disagree
    □ Completely Disagree

12. **I think the government policies (mainly 6 administrative policies) of Bunkyo did a good job on the promotion of tourism.**

    □ Completely Agree
    □ Agree
    □ I don't know
    □ Disagree
    □ Completely Disagree

13. **If it is possible, I would like there are more promotion policies for the development of tourism of Bunkyo.**

    □ Completely Agree
    □ Agree
    □ I don't know
    □ Disagree
    □ Completely Disagree

2. Basic information

Gender   □male □female

Age   □10-19 years old   □20-29 years old   □30-39 years old   □40-49 years old   □50-59 years old   □60-69 years old   □above 70 years old

Occupation   □Civil servant □Teacher □Executive staff □Association members □Commerce and industry business □Agriculture Forestry and Fisheries □Free trade (doctors, lawyers and other) □SOHO □Moonlighting □professional housewife □University students or graduate students □Specialized school students □high school students □Others(please write_____)

Length of Stay in Tokyo   □Less than 1 year □1-3years □4-6years □6-10years □11-21years □more than 21 years

Education Degree   □Elementary school   □High school   □University (College) □Master   □Doctor

Month Income   □less than 200000 JPY   □210000-400000JPY   □more than 410000JPY

Address   □Kouraku □Kasuga □Koishikawa □Hakusan □Senngoku □Suido □Kohinata □Otsuka □Sekiguchi □Mejirodai □Otowa □Hongo □Yoshima □Nishikata □Mukogaoka □Yayoi □Nezu □Sendagi □Honkomagome