A STUDY ON EVALUATION OF STREETSCAPE IN JAPAN AND CHINA

(日本と中国における街路景観の評価に関する研究)

山梨大学大学院

医学工学総合教育部

博士課程学位論文

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International Research Centre
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Abstract

Development of urban transport infrastructure has been progressing rapidly accompanied by large economic growth in recent years. Urban transport infrastructure development will not only bring convenience to the community, but also impact the living environment. Therefore, it is important to build a transport infrastructure that has an appropriate trade-off between its function and the conditions of the urban environment. Nowadays, the urban transportation faces many problems due to the excessive development of economy. Since the number of cars on the roads keeps increasing, the improvements in road size, quality, and quantity have steadily progressed, while pedestrian space has been neglected. In many situations, in order to provide enough space to the traffic, the width of sidewalk along the main streets often has to be set far below the required standard. Besides that, the pedestrian space is often occupied by bikes and advertisement boards. These result in the low comfort of the streetscape. We believe that, during the transport development, it is important for city authorities to plan and conduct qualitative maintenance (with emphasis on landscape) along with quantitative maintenance (with emphasis on efficiency). In order to do that, clarifying the importance of physical factors on evaluation of streetscapes and their effective operation is necessary. At the same time, we know that a city street by itself is nothing, it is an abstraction, and it means something only in conjunction with its users, city dwellers. People's evaluation on the streetscape is precious and important. City authorities should plan and conduct maintenance with respect to people's demand.

As typical developed and developing countries, Japan and China are facing the same problem regarding streetscapes, and chronic congestion is now a feature of the roads in these two countries. It would be prudent for both Japan and China to conduct both qualitative and quantitative maintenance of their urban infrastructure, although they are in different stages of economic development. We have seen that a vast amount of scholarships has been devoted to evaluate streetscapes in Japan and China. However, the physical factors influencing streetscape evaluation are different in each country, therefore, China cannot directly apply Japan's experiences without any processing. Thus, it is important for us to understand the

similarities and differences between the target cities. In this study, we consider the similarity in many aspects such as culture, population, transportation infrastructure, etc. Chengdu, China and Tokyo, Japan were selected as our target areas and a questionnaire on main roads and familiar narrow streets was conducted in both cities. Among the questionnaire respondents, 100 graduate students are from the Southwest Jiaotong University in Chengdu, China and 159 undergraduate students enrolled in the Faculty of Humanities and Environment at Hosei University, Japan. The survey was conducted in August 2011, and it requires respondents to think about the most impressive street they knew in their respective cities and fill in the questionnaire accordingly. Impressive main roads are those with more than 3 lanes and sidewalks, and impressive familiar narrow streets are those with less than 2 lanes and sidewalks. In addition, the questions were graded on a five-grade evaluation scale based on the semantic differential (SD) method.

Given the survey, we will analyze physical influencing factors and obtaining useful information on qualitative maintenance to identify the factors for streetscapes evaluation, which will provide suggestions for street maintenance. To achieve this goal through the questionnaire of streetscape in Tokyo Japan and Chengdu China, the following specific objectives are set up: 1) to clarify the physical factors affecting the streetscape evaluation, 2) to reveal the distinction of influential physical factors between Japan and China, and 3) to introduce a new methodology to evaluate streetscape.

Multiple linear regression analysis is one of the most popular methods for performing data analysis of questionnaires. However, it cannot construct a model with an interaction effect and nonlinear structure. Among the perceptual data, if there is an external criterion, the relationship between the explanatory variables and responses is often non-liner. As a result, the classification and regression tree has been extensively used in the literature. Nevertheless, this method has a significant limitation, low prediction accuracy. Therefore, the exploration of statistical model that can be interpreted easily and superior in the prediction accuracy is essential.

In this research, the similarities and the differences on the streetscapes in Japan and China were understood with Mann-Whitney Wilcoxon test. Following that, Breiman’s random forests method, one of the most famous ensemble learning methods, was used to analyze the data obtained from the survey on main roads (primary and district distributor roads) based on factor analysis method. It is shown that the three chief factors affecting evaluation of streetscapes are comfort, beauty, and activity. There is no significant difference in comfort evaluation and beauty evaluation between two cities. For comfort, the number of shops strongly influences the evaluation of comfort for both Tokyo and Chengdu, and comfort plummets with too many shops. Density has a strong impact on comfort in Chengdu, and lower density leads to higher comfort. We also get that for Chengdu, comfort of streetscapes is strongly influenced by landscape and spatial situations. For beauty, the density has the strongest influence in both Tokyo and Chengdu, and beauty reduces heavily at a great scattering. An increase in the quantity of houses decreases the level of beauty in Tokyo, but increases the one in Chengdu. In other words, the impact of building usage was stronger in Tokyo than in Chengdu. For activity, the activity score of Tokyo was significantly higher than that of Chengdu, and the congestion of street has the strongest influence for both Tokyo and Chengdu, with decreasing activities, streets become vacant.

Regarding the survey on local distributor roads, conditional inference trees method was used. The conditional inference tree which consists of binary split tree based on the permutation test statistics can be explained influencing factors for local distributor roads in the form of production rules. We found that for the perceptual items (comfort, beauty, affinity), Tokyo has higher satisfaction, while for the functional item (ease of walking), Chengdu is much better than Tokyo. Beautiful buildings play a positive role in the comfort and beauty of streetscapes, while the bad pavement of sidewalk has negative affect on the comfort and the beauty of streetscapes. Maintenance of sidewalk pavement is a key way to eliminate the negative impression of comfort and beauty in local distributor roads. The impact of the beauty of the architecture is much more influential to the comfort evaluation in Chengdu's local distributor roads than that in Tokyo. Maintenance of roadside trees, as a positive factor, is important to comfort evaluation of local distributor roads. In the aspect of affinity, Tokyo has a stronger affinity of the local distributor road than Chengdu. In Tokyo, the quantity of shops has a positive effect on affinity, and in Chengdu, the beauty of buildings plays the positive role. The ease of walking is heavily impacted by the obstacles of local distributor roads. In addition to that, by strengthening the quality of sidewalk pavement, the ease of walking could be improved dramatically.

The fundamental knowledge we found about the differences and similarities between the evaluations of streetscapes in Japan and China will be useful for streetscape maintenance and will be a valuable lesson for the streetscape development of China. In order to achieve the ultimate goal that providing maintenance method of streetscape in both Japan and China, extracting the common influential factors and constructing the international model, more regions in Japan and China even in the worldwide covering more age groups will be studied by the same method and the physiological- psychological experiments based on objective data of this research will be conducted in the future.

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Chapter 1 Introduction

1.1 Background

In the past decades, people in all over the world have been sacrificed by the environment change because of economic developments. Our living environment is gradually being surrounded by noise, pollution, congestion and so on. In recently years, with improved living standards and the gradually harsh living environment, people started to realize that the economic growth at the expense of environment will not last long and what we need is sustainable development. As a result, the environment and landscape has attracted our extensive attention worldwide. Many countries have already established laws related to landscape. For example, in Japan, there has been the Landscape Act since 2004 to preserve and maintain landscape.

Jacobs says that if a city's streets look interesting, the city looks interesting; if they look dull, the city looks dull (1961). Streets, the main public place of a city, play an important role in our daily lives. At the same time, because of the pursuit of a healthy life, more and more city dwellers prefer walking on occasion. Consequently, as an essential part of the walking environment, street landscaping, especially from the viewpoint of pedestrian become more important.

In nowadays, the situation of streets faces many problems due to the excessive development of economy. With increasing number of cars, improvements in road size, quality, and number have steadily progressed, while pedestrian's space has been neglected. In many places, in order to provide enough space to traffic, the width of sidewalk along the main streets often has to be set far below the required standard. Besides that, pedestrian's space is often occupied by bikes and advertisement boards. Those result in the low comfort of the streetscape.

Because roads are city property, it is important for city authorities to plan and conduct qualitative maintenance (with emphasis on landscape) along with quantitative maintenance (with emphasis on efficiency). The starting point of Corbusier's design work's aesthetic concept is the visual beauty and lack of human touch (Ashihara, 1979). Ashihara advocates the aesthetics of townscape from the point of dwellers, and he emphasizes the human existence. Therefore, we got that a city street by itself is nothing, it is an abstraction, and it means something only in conjunction with its users, city dwellers. People's evaluation on the streetscape is precious and important. City authorities should plan and conduct maintenance in accordance with people's demand.

As typical developed and developing countries, Japan and China face the same problem in relation to streetscapes, with high economic growth and a rapid progress in road and street infrastructure. Chronic congestion is now a feature of Japanese and Chinese roads. It would be prudent for both Chinese and Japanese cities to conduct both qualitative and quantitative maintenance of their urban infrastructure, although they are in different stages of economic development.

Identification of factors that are used to evaluate streetscapes and their effective operation is important for any country. Analyzing physical influencing factors and obtaining useful information on qualitative maintenance are means to achieve these factors.

1.2 Motivation

The motivation to this research is rooted from three-fold reasons. Firstly, make a proposal of maintenance method of streetscape in Japan and China. Secondly, extract the common feature that affects the streetscape evaluation. Finally, construct an international model that can be applied in other places in different periods.

(1) Make a proposal of maintenance method of streetscape in Japan and China

In large Chinese cities, because of huge population, high density habitation, and traffic increases by the economic growth, streets are always congested. In the Chinese higher education system, discipline setting of city construction is emphasized on the function design such as structure, materials. There are very few experts of environment and the landscape in the field of traffic. Unbalance in the engineer's education is obvious. Overall, it is hard to say that the study on the traffic environment side develops enough in scientific research.

In Japan, a vast amount of scholarships has been devoted to the evaluation of streetscapes. Meanwhile, in the aspect of planning, city dwellers can also take part in it. They are conscious of the streetscape's importance. However, after the World War II?, the rapid economic development has also brought some problems. Especially, in large cities, public transport has been developed well, but the transport infrastructure has been emphasized on function and neglected the environment.

We know that when the urban development is in a prosperous period of economic growth, maintenance from two sides of function and environment is important, because it can serve as a cultural heritage for future generations. For example, Champs Elysees in pairs France, Jozenji Street in Sendai Japan, and Ginza Boulevard in Tokyo Japan, they are the typical streets with good landscape. However, because of the restrictions from different quarters, it is difficult to take account of every aspect in all street maintenance. We wonder whether we can obtain the major factors that affect the streetscape evaluation in Japan and China, and then put them in the first place in streetscape maintenance.

(2) Extract the common influential factors that affect the streetscape evaluation

Hitherto, many anthropologists and psychologists have approached the human nature. A vast amount of scholarship has been devoted to the investigation on human nature, human culture, human activities, human mind and human universals. The philosopher-anthropologist Bidney argues that culture should, at least partially, be understood as the dynamic process and product of the self-cultivation of human nature (1947). Brown contributes to the discovery of presumably universal features of the human mind. He uses an analogy to suggest how culture and nature run together and says that the insights into human nature that result from this research are in turn providing insights into the motivation, origin, or character of a wide variety of human activities—and into the particulars as well as the universals of human culture (1991, 2004).

According to their researches, we have reasons to believe that there are commonalities in the streetscape evaluation even in different cultures, different regions and by different people. Therefore, we wonder whether we can extract the common influential factors from the various factors that affect the streetscape evaluation.

(3) Construct an international model for streetscape evaluation

It is evident that we can get a result by analysing the data from survey respondents. In case the respondents were different, will the result be the same? If there is a big change in the result, we need conduct the analysis again for different places. Whether we can construct a model to adapt to the change of respondents, the regions even the times, like the hypothetical model showed below?

The hypothetical model is defined as:

$$E = F(x, y, z, \ldots) + e + \varepsilon \tag{1.1}$$

Where E: evaluation of the streetscape

x: physical factors of streetscape

y: region

e: individual difference

ε: error

1.3 Objective

This study aims at obtaining the influential factors to provide suggestions for street maintenance. To achieve this aim through a questionnaire survey of streetscape in Tokyo Japan and Chengdu China, following specific objectives:

(1) To clarify the physical factors affecting the streetscape evaluation

(2) To reveal the distinction of influential physical factors between Japan and China

(3) To introduce a new methodology to evaluate streetscape

1.4 Dissertation outline

This dissertation consists of six chapters. The brief outline of each chapter is given below:

Chapter1: Introduction

This chapter sets a background for the whole study by highlighting the importance of streetscape for our living environment, the great significance of streetscape evaluation for street maintenance and the necessity of streetscape evaluation research in Japan and China. It further describes the motivation and objectives of this research and presents the outline of the subsequent chapters. Finally, in order to make a clear understanding of the study, the technology route of the research framework is presented.

Chapter2: Literature review

It presents and details the existing researches from two aspects. One is studying on factors analysis for streetscape evaluation and the other is studying on experiment method and evaluation method. Then the further investigation is done in these two aspects respectively. At last, it summarizes the insufficiencies of the existing researches.

Chapter3: Study design

This chapter describes the survey regions, survey method and survey items of the questionnaire. Tokyo, Japan and Chengdu, China are set to be the survey cities. The reason of selecting these two cities is explained from area, population, history, streetscape situation and the transportation infrastructure in urban areas.

Chapter4: Streetscape Evaluation of Primary distributer road and district distributer road

This chapter focuses on the streetscape evaluation of wide roads in Tokyo and Chengdu. Factors affecting evaluation of streetscape are estimated by factor analysis method at first. Following that, the random forest method is used to process the questionnaire results. With the random forest method, variable importance and partial dependencies are analysed to evaluate physical factors that affect evaluation of streetscape.

Chapter5: Streetscape Evaluation of local distributor roads

The object of the study in this chapter is the streetscape evaluation of narrow roads in Tokyo and Chengdu. The similarities and the differences of sensitivity on the streetscapes in Japan and China are understood with Wilcoxon test. After that, conditional inference trees method is used to analyse the data obtained from the survey.

Chapter6: Conclusions and recommendations

This chapter summarizes the contributions made through this study and suggests the need of further investigations.

In order to make a clear understanding of the study, the technology route of the research framework is presented is Figure 1.1.

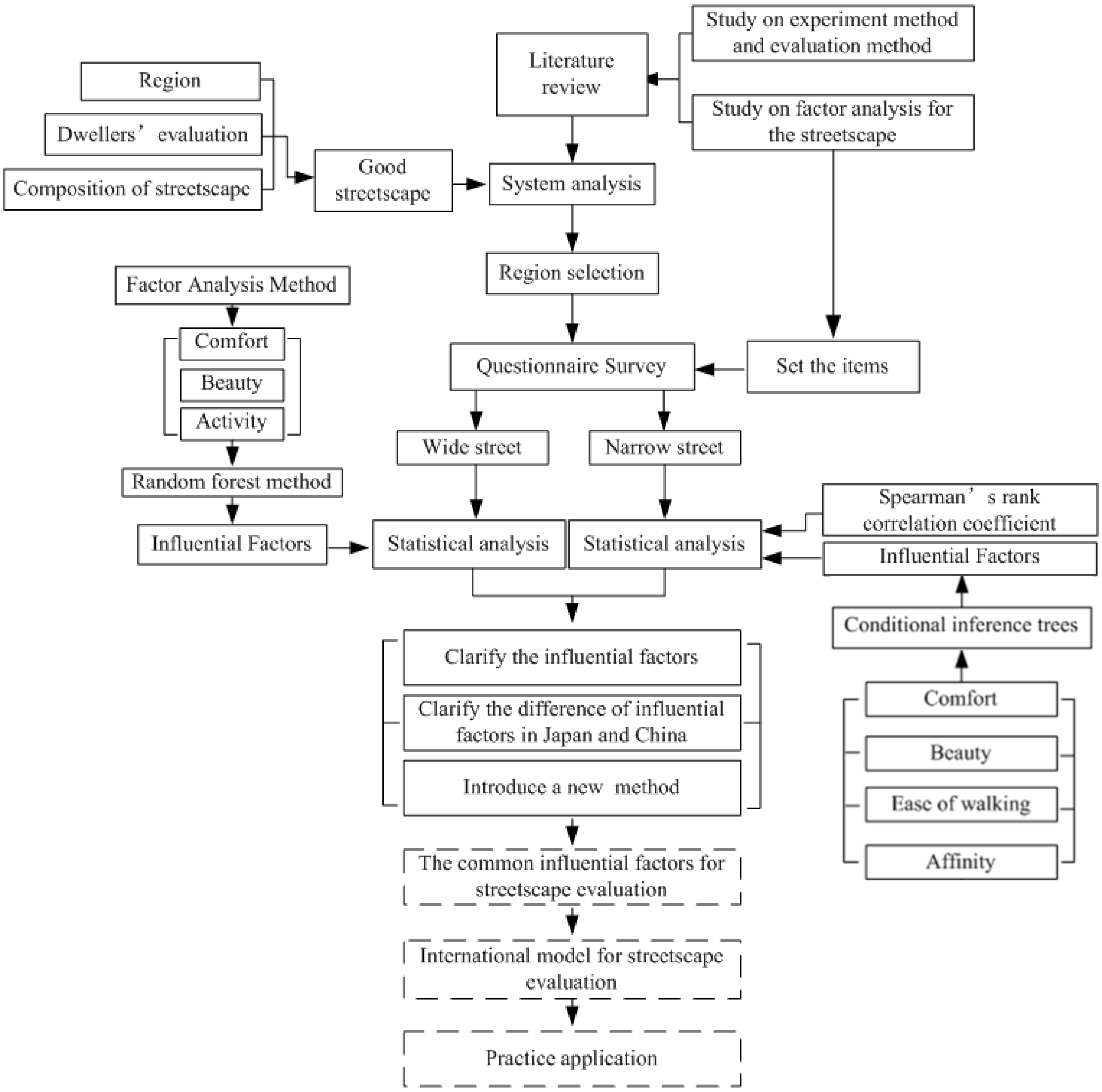


Figure 1. 1　Structure of dissertation

Chapter 2 Literature Review

In this chapter, we sort out the existing research on the streetscape evaluation. The existing research is organized into research on the factors analysis, experiment method and evaluation method with the goal of streetscape evaluation these three aspects.

2.1 Study in the streetscape constituent factors

Previous research has suggested that the analysis of streetscape factors plays an important role in the streetscape evaluation. Hitherto, massive research results in the field of streetscape factors analysis have been accumulated.

2.1.1 Streetscape evaluation based on SD method

The semantic differential (SD) method is now one of the most widely used scales used in measuring the connotative meaning of things and concepts. It measures people’s reactions to stimulus words and concepts in terms of rating on bipolar scales defined with contrasting adjectives at each end (Summers, 1970). The bipolar adjective pairs can be used for a wide variety of subjects.

In the field of streetscape evaluation, the SD method is used to analyse the influential factors in numerous studies. In common, the research approach is, setting the streetscape as the object, using the onsite survey, slide show, CG images or montage to show the object to the respondent, then analysing the potential evaluation factors-comprehensive evaluation factors such as comfort, activity, beauty, prosperity via the SD method and factor analysis method.

In China, the studies in the streetscape evaluation are remains at the phenomenon description level. Few are quantitative researches. Till recent years, SD method began to be applied to the study of the streetscape. Wang and Zhang (2011) select eight representative streets in Shanghai city and 36 students as respondents in which half are architecture majors. 4 groups (the shape of the street space, atmosphere, characteristics, and street environment) composed by 20 bipolar adjective pairs are adopted to survey the space perception via the SD method. Then construct the relevant analysis between 4 perceptions and 9 objective indexes of every street. The research reveals that the street length influences the perception most.

In Japan, a large number of scholars have conducted research in this area. As early as the 1970s, Kitamura (1976) gave more details on the application of the SD method. Shinichi K. selects 11 bipolar adjective pairs 'beautiful- ugly', 'orderly-messy', 'clean-dirty', 'bustling-deserted', 'active-hushed', 'human-like-no human-like', 'like-dislike', 'charming-dull', 'easy to be familiar with- hard to be familiar with', 'calm-restless', 'feel the warmth-feel the coldness' based on the SD method, and obtains 'harmony', 'activity', 'affinity' these three common factors by factor analysis. The relationship between spatial factors and indexes is surveyed via multiple regression method. The results show that 'harmony' trends to be affected by the height of building, colour, texture, variety of the texture, quantity of the nature, and quantity of the billboards. 'Activity' maybe affected by the number of pedestrian, quantity of billboards, colour and the variety of the texture. And it is possible that 'affinity' is affected by the amount of nature, texture, colour, the variety of colour, the variety of texture and the height of building.

Funakoshi and Tsumita (1987) carry out a correlation test at five shopping streets and five residential streets by the use of 13 bipolar adjective pairs which are classified into such psychological factors as design factor, urbanity factor, openness factor and so on. The correlation coefficients between 13 psychological factors and 21 space elements at the shopping streets and 15 space elements at the residential streets, respectively, are calculated on the basis of the correlation test data and physical analysis data. Moreover relations among space elements on the street spaces are made clear with the cluster analysis method on the correlation coefficients. At last 26 estimate formulas are obtained by the multiple regression analysis method with psychological factors as independent variables and space elements as dependent variables. As a result of the analyses, relations between psychological factors and space elements on the street spaces can be explicated qualitatively and quantitatively. In conclusion, sidewalks, trees and shrubberies along the streets and pedestrian buffer spaces between sidewalks and buildings are very important elements and can be enhance the enjoyment, quality of space, openness and atmosphere on the street spaces. Utility poles, signposts and street installations disturb the unity, composure and continuity on the street spaces, etc.

By paying attention to disorder/order of streetscapes, Matsumoto et al. (1991) evaluate streetscapes using a factor analysis method. Three factors— "passive capacity," "tradition and disorder," and "activity" are derived. At last, the following results are got. Disorder is decided by distribution form and impression of disorderly elements. Regularity is influenced by physical situations of not only regular ones but also disorderly ones. Disorder and regularity in street views are decided by mutuality of physical situations of individual elements.

Maki (2006) assesses the influence of "fatigue" on streetscape evaluation. In the experiment, 24 streetscape slides are rated before and after the two hours VDT (Video Display Terminal) task to clarify whether fatigue mediates the streetscape evaluation and whether fatigability can explain the individual difference observed during the evaluation. Together with the quantitative evaluation on fatigue, SD method based streetscape evaluation is also constructed. Thus obtained evaluation scores are analysed by principal component analysis. According to the ratings obtained before and after the VDT task, it has been pointed out that people who get easily tired by fatigue experiments tend to like nostalgic scenery after work, whereas people who do not tire easily tend to dislike urban sceneries and pedestrian traffic.

Amano et al. (2010) apply covariance structure analysis to the streetscape SD method and points out that "the ease of walking" and "atmosphere" affects the pleasure derived from streetscapes. The desire to return to streetscapes was also considered in his research.

2.1.2 Multi-factors

Yang et al. (2012a, b) investigate the factors of identification on streetscape, and clarify the relationship between streetscape identification and sensitivity evaluation. In the psychological experiment, the streetscape of Chengdu, China has been set as an object of the study. They select 32 students as respondents to classify the 120 sheets of typical streetscape images by operating the method of binary tree classification 3 times. At the same time the degree of satisfaction of those streetscapes from 'comfort' and 'activity' these two factors are evaluated by using five-stage method. Three factors 'the width of sidewalk', 'the presence of shops' and 'the quality of the pavement' are found to be the influential factors on identification. It also reveals that the quality of the pavement is a significant impact on the comfort of streetscape. The width of a sidewalk is shown to have a large effect on streetscape's comfort and range of activities. Moreover, although the "existence of shops" had a positive influence on the range of activities, it gives a negative image to the comfort of streetscapes. Furthermore, it is found that surface of sidewalks has a strong influence on its comfort.

Oku (1985) reports on the influence of townscape elements on the estimation of townscape by means of the montaged slide. He evaluates 'unity', 'intimacy', and 'preference' by rating the retouched photographs from elements such as top of buildings (skyline), trees, arcade, windows, surface of road, landmark, billboard, utility poles and overhead wires. The research suggests that the higher a degree of unity becomes, the higher a degree of intimacy and preference become, but if a degree of unity becomes too high, a degree of intimacy and preference will be reduced.

Fujii and Kurita (2010) conduct a study on landscape evaluation of the approach to temple in the central commercial area of temple town. In their research, they consider the effect of landscape elements on landscape evaluation by analysing the structure of landscape evaluation with covariance structure analysis. The following conclusions are obtained. Utility among local residents increased due to the minimization of signboards, regulation of building heights, increasing the number of trees along the streets, and prohibiting advertisement in bus shelters in improvements of the landscape along the approach to the temple. Residents have various reactions to the regulation of building heights. Reducing the number of signboards meets with general agreement. That reduction in the number of signboards and building height limits has the effect of raising the comprehensive landscape evaluation, while an increase in signage has the opposite effect.

2.1.3 Single factor

Nemoto (1985) develops a new planning method that makes street scenes in a residential area beautiful and comfortable with green. The research focuses on the greenery. First, they make a psychological experiment using the SD method with a lot of montage slides.

Secondly, two indexes 'visibility ratio of street trees' and 'load side planting ratio' are defined and these two indexes are analysed via multi regression analysis. As a result, it reveals that people need green visibility ratio about 25%, and load side planting ratio can be calculated according to green visibility ratio.

Aoki (1989) focuses the research on the greenery massive impression. In the experiment, 20 typical streets in 23 wards of Tokyo are selected. 10 respondents are required to rate the massive impression of greenery onsite. After interviewing the respondents, the criterion for rating is obtained. By differentiating the street space, the result that greenery massive impression is not only connected with greenery occupancy ratio but also connected with the variation of the greenery occupancy ratio is obtained.

Matsukawa et al. (1993) analyse the extent of the visual range on streets in urban area using 3-dimensional simulation model. In their research, visual range is defined as the rate of interrupted sky. And this index of each selected street is calculated for various simulation patterns using 3-dimentional buildings data of Oita city.

Zhang et al. (2005) discuss the heights of buildings lining Nandajie Street in Xi'an China. The heights of the buildings are changed in each influenced range of streetscape. By clarifying the influences of the streetscapes developed from the combinations on men's psychological evaluation, the estimation is performed for desirable combination of the heights of the buildings. In order to achieve the examinee's feeling as real as possible, VR (Virtual Reality) system is adopted in the evaluation experiment.

Kita et al. (1999) clarify relationships between estimation and color composition in streetscapes regarding the range of basic and point colors in a collection of building walls.

2.2 Experimental method

After reviewing the existing researches, we can find that when exploring the streetscape, psychological evaluation is often conducted at first. In order to obtain the more accurate data, how to show the streetscape to the subjects as real as possible becomes important. Next, we want to get some details about the experimental method to streetscape evaluation.

2.2.1 CG, montage, video

In amount of research, we can find that slide is often used to show to the subjects with CG (computer graphics), montage, and video.

Nishio et al. (1999) conduct the psychological experiment to discuss landscape from the viewpoint of environmental engineering. Seventy two slides of streetscape are shown to the subjects in the experimental chamber adjusted to two levels of traffic noise, vegetation (with or without vegetation) and temperature (26℃, 28℃). Evaluation is made on 17 pairs of adjectives of seven point scales. Subjects are 25 healthy male students, half of whom specialised in architectural course. Result shows that the evaluation structures of the two subject groups differs each other in the evaluation of vegetation.

In the research of Endo and Yamada (2008), evaluation experiment of SD method is conducted by on-site and using slide aimed to verify the validity of the using slide evaluation method when evaluating psychological effect by roadside trees. From the result of factor analysis of each evaluation experiment result, psychological, view, spatial evaluation factor is extracted, and evaluation structure of roadside trees is no big difference in each methods. Moreover, from the result of cluster analysis by using factor score of psychological and view evaluation factor, the evaluation result of each method is brought together in the same cluster on most streets, and it is suggested that validity of using slide evaluation method is high. Because it is not possible to evaluate factors accurately from the slide such as the existence of living things, street information on pavement width and tree height, the difference in each method is seen on a part of street.

Tajima and Asakura (1985) compare the evaluations on the streetscapes presented by different method and analyse the influences each presentation has to change the evaluation on the streetscape. They make some experiments for evaluations on streetscapes using by SD method and eye mark recorder (EMR). And find that videotape recorder (VTR) is an effective method to present streetscapes.

Kagawa et al. (2009) analyse the influences on attractive information elements such as signboards by using pictures of 8 streets in Jiyuugaoka shopping area, three variables namely ‘the ratio of disordered area’, ‘the ration of stimulatingly-colored area’ and ‘the ratio of calmingly ’.

Mitsuhashi (1992) aims to develop a quantitative evaluation method of townscape by applying landscape simulation to the modelized urban scape. Practically, a 3D model of the urban space is input as data. Buildings are projected to a cylinder which has the view point as its center. At the same time, distance and angle between the view point and the projected object is measured. According to the resultant data, the buildings are evaluated from their potential abilities to become landmarks.

Hirate and Yasuoka (1986) make experiments on measurement of psychological quantity with using photomontage slide films of street-vistas and introducing of a new structural model of psychological evaluation. The possibility that psychological quantity is connected to simple physical quantity is shown. The objects in experiment are black and white photomontage slide films. After obstructive elements (i.e. utility poles, billboards, and original roadside trees etc.) retouched, roadside trees are montaged. Experiments are made into two parts. At part 1, backgrounds, trees, planting arrangements on the objects are changed and in part 2, width of road and planting arrangements, too. At last, the best width and best interval of planting are obtained.

2.2.2 Pilot experiment

A pilot experiment, also called a pilot study, is a small scale preliminary study conducted in order to evaluate feasibility, time, cost, adverse events, and effect size (statistical variability) in an attempt to predict an appropriate sample size and improve upon the study design prior to performance of a full-scale research project (Hulley, 2006). In reseat years, this method has been used in streetscape evaluation widely.

Amano et al. (2010) think that landscape is influenced by various behaviours of those who are connected with that place and the essential method to improve landscape should be to lead their attitude modification on landscape. Their research is an examination of the possibilities that their attitude modification on landscape lead a landscape-improvement through a social experiment that is one of the psychological strategies. The results indicate that behaviours of shop keepers lead modification of pedestrian impression on streetscape and attitude change of shop keepers. The result reveals that an induction of attitude modification is effective against a landscape-improvement.

In order to understand the problems for making better use of the public space in the future, Watanabe et al. (2001) report an experiment for activating the city center by 'Citizens Forum on Urban Design ' in Chiba City. In this study, they analyse two points from the process. The first is the necessary conditions permitting the use of public space and the second is the effect on urban design. The results are shown as follows. It is the important condition that the projects has 'Public interest' which is shown as 'participation of administration' for use of public space and the experiment succeeds in making 'the public life scene'.

2.3 Statistical method

The statistics plays a decisive role in streetscape evaluation. Fujii and Sakai (2002) examine the causal relationship between the physical measurements on landscape elements and the subjective-psychological judgement on landscape evaluation with two analytical methods, namely the conjoint analysis which has the availability deciding the utility of each landscape element and the covariance structure model which has the capability of flexibly forming the model. In their study, they select five landscape element of the streetscape as attributes, make eight landscape images by means of combining levels of five landscape elements using the image processing, and carry out the evaluation experiment of streetscape. As a result, the availability and usefulness of each analytical method are confirmed.

Maki et al. (2003) propose a streetscape evaluation structural model named Card Pick up model. This model has three remarkable points which are different from the linear combination model which has been most popular model of evaluation structure.

1. The meaning of constructs expressed on four levels, 'influence over evaluation', 'character', 'situation' and 'cognitive'
2. The constructs being used for evaluation change dynamically depending on the feature of the streetscape
3. 'Average of utilities rule' is adopted instead of 'addition of utilities rule' to calculate the

preference.

In the research of Yang et al. (2012a), multivariate regression tree is employed to process and analyse the identification data which is collected by the result of image classification. As a result, the width of sidewalk, the presence of shops, and the quality of the pavement are found to be the influential factors on identification. And it is also reveal that the quality of the pavement is a significant impact on the comfort of streetscape. Yang et al (2012b) conduct another study on cognitive structure of streetscape in Chengdu China by multivariate adaptive regression spline (MARS) and obtain the physical factor which affects the degree of satisfaction of a streetscape.

2.4 Trends of papers on the evaluation of landscape

Papers of landscape appreciation began to be published in the decade of the 1960s. Till now, this subject, psychological evaluation of landscape, has spread into wider scientific research field. In order to provide information to newcomers of this research, many scholars try to summarize the works.

Aoki (2007) summarizes recent trends of English papers on the psychological evaluation of landscape. The paper reviews recent interesting studies in terms of psychological tests referred to in Environment and Behaviour, J. of Environmental Management, Landscape and Urban Planning, Landscape Journal, Landscape Research, and some other scientific journals from 1996 to 2005, and summarizes those papers according to the key subjects, i.e., the effects of respondents' attributes, the descriptors of appreciation, the sampling of landscapes and their presentation methods, the predictive model of psychological response using the physical features for physical planning, and others.

Li et al. (2011) take research articles published in various societies and magazines in Japan during fifty years from 1960 to 2010 as subjects, and make two genealogical tables aimed at counting publishing units. Based on the mastery of previous researches, the paper analyzes and forecasts the trends of research on road landscape. Finally, one hundred and forty papers during fifty years are classified and the development history of researches on road landscape in Japan is concluded. The paper helps grasp the latest research trends and determine the necessary research methods which should be adopted when evaluating road landscape in future.

Coeterier (1996) focuses on the perceptual attributes and physical elements and refers to 70 papers. Aoki (1999) overviews the entire procedure of the experiment and refers to 73 papers. Palmer and Hoffman (2001) focus on reliability and representation validity and refer to 71 papers.

2.5 Summary

2.5.1 Outline of existing research

Figure 2.1 shows the outline of the existing research. As can be seen from the figure, there are four kinds of streetscape evaluation image, first-hand experienced streetscape via on-site experiment, actual photographed image, virtual space image by computer graphics (CG), and montage image composited by CG or other images in the captured image. In particular, with the CG image and montage image, factor is easy to be controlled comparatively. Method of evaluation experiment on streetscape is divided into two types, SD method based on cognitive evaluation and cognitive classification. Because the primary goal of the cognitive classification is to classify common characteristics according to type, the subsequent statistical analysis method is limited. On the other hand, since the goal of the experiment by the SD method covers a wide range, various statistical analyses can be used.

According to the presence of the external criterion, the selection of statistical analysis method is different. Factor analysis, principle component analysis, and latent structure analysis are often used to explore the latent structure of streetscape evaluation. When survey the impact of spatial characteristics, multiple regression analysis, canonical correlation analysis, hayashi’s quantification methods I, classification and regression tree (CART), and multivariate adaptive regression spline are frequently adopted. Cluster analysis, especially the hierarchical cluster analysis is used in streetscape image classification. At the same time, multidimensional scaling and correspondence analysis are graphical techniques. They are designed to reduce dimensionality and portray relationships among observations or variables and often used before the cluster analysis to provide classification basis for cluster classification.

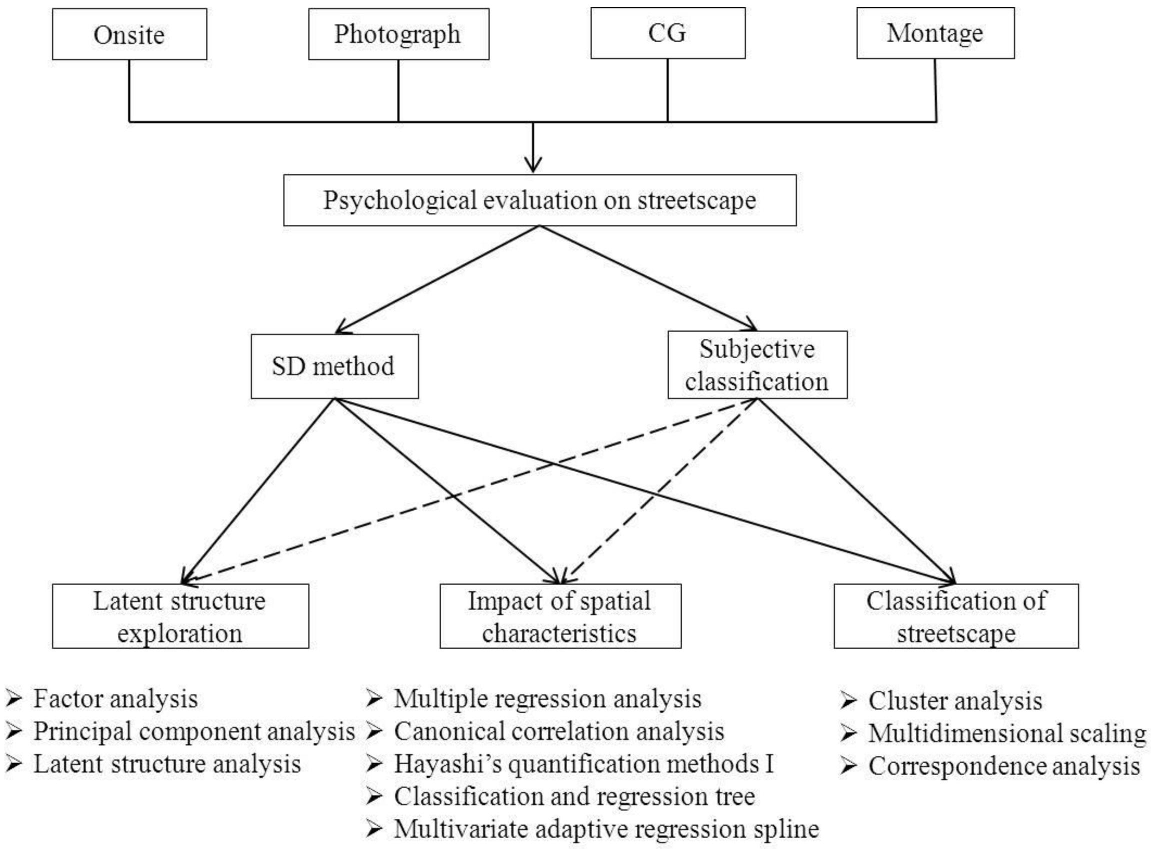


Figure 2. 1 Outline of the existing researches

2.5.2 Deficiency of existing research

When pay attention to streetscape image used for an experiment, in many studies, dozens of pieces of streetscape images are used. However, the real street scene covers wide range, it cannot be said that is enough numbers to examine those influence closely. Therefore, in the articles that mentioned in 2.2.1 section, the spatial factor that is considered to affect the evaluation is controlled by making CG image and montage image. However, it does not actually exist and has no objective reality. It is thought has not much effect to the experimental results, such as SD method. If large numbers of images are shown to test subjects for evaluation, it is probable that it not only costs a great deal of labour but also fatigues test subjects. Therefore, when the method comprising evaluating many images is adopted, some measures to eliminate external factors for subjects such as 'fatigue' are required.

Regarding the statistical method for streetscape evaluation, principle component analysis or factor analysis is used to explore latent structure after rating the streetscape images by SD method. Multiple regression analysis is often used under the presence of external criterion. Sakai and Fujii (2002) point out that among the sensitivity data, if there is an external criterion, the relationship between the explanatory variables and responses is often the non-liner. As a result, the classification and regression tree has been extensively used in the literature. However, this method has a significant limitation, low prediction accuracy. Therefore, the exploration of statistical model that can be interpreted easily and superior in the prediction accuracy is necessary.

Regarding the international comparisons research, Shidei (1981) compares the attitudes toward nature among Japan, France, and Germany. Aoki and Petrova (2010) conduct a comparison of natural landscape appreciation between Russia and Japan. However, no attempt has been made to identify factors influencing streetscape evaluation internationally. In the streetscape evaluation, in order to obtain the common points and absorb experience and new ideas, the international comparison on the streetscape evaluation via the same method is extremely important.

Chapter 3 Study design

3.1 Subject region for questionnaire

Tokyo Japan and Chengdu China are selected as the target areas for this survey. Tokyo, officially Tokyo Metropolis is one of the 47 prefectures of Japan. Tokyo is the capital of Japan, the center of the Greater Tokyo Area, and the largest metropolitan area in the word (United Nations, 2009). Chengdu is the capital of Sichuan Province, which is known as the "Heavenly State" (Tian Fu Zhi Guo). Being the natural habitat of cute giant pandas, it is located in the west of Sichuan Basin and in the center of Chengdu Plain. Subsequently, Tokyo and Chengdu will be introduced briefly. The relative location of Tokyo and Chengdu is shown in figure 3.1.

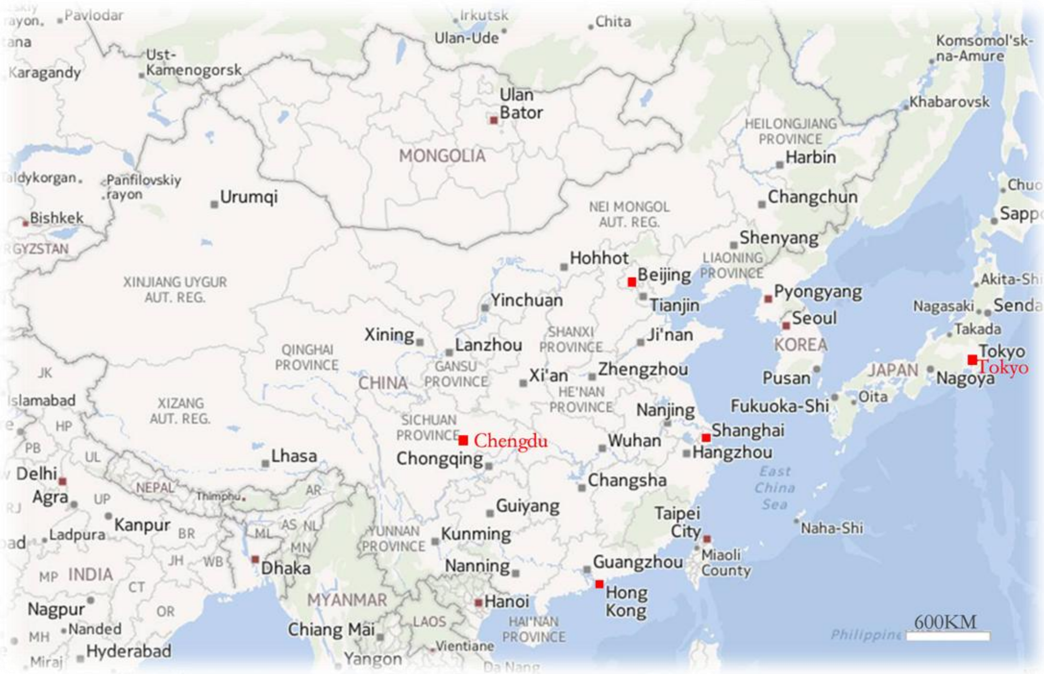


Figure 3. 1 Relative location of Tokyo and Chengdu

3.1.1 Brief introduction of Tokyo city

With a population of about 13 million, Tokyo has grown into the largest of the 47 prefectures of Japan and indeed one of the greatest metropolises in the world. Comprising 23 special wards, 26 cities, 5 towns, and 8 villages, Tokyo is the center of various activities in Japan including politics, economy, and culture.

1. History

Tokyo was originally a small fishing village named Edo. Edo was first fortified by the Edo clan, in the late twelfth century. In 1590, Tokugawa Ieyasu made Edo his base and when he became shogun in 1603, the town became the center of his nationwide military government. During the subsequent Edo period, Edo grew into one of the largest cities in the world with a population topping one million by the 18th century. Tokyo became the de facto capital of Japan even while the emperor lived in Kyoto, the imperial capital (Sorensen, 2002).

2. Climate

The majority of mainland Tokyo lies in the humid subtropical climate zone, with hot humid summers and generally mild winters with cool spells (Peel et al. 2007). The region experiences a one-month seasonal lag, with the warmest month being August, and the coolest month being January. Annual rainfall averages nearly 1530 millimeters, with a wetter summer and a drier winter. Snowfall is sporadic, but does occur almost annually.

3. Geographical distribution of industrial development

Tokyo is a major international finance center, houses the headquarters of several of the world's largest investment banks and insurance companies, and serves as a hub for Japan's transportation, publishing, and broadcasting industries. During the centralized growth of Japan's economy following World War II, many large firms moved their headquarters from cities to Tokyo, in an attempt to take advantage of better access to the government. This trend has begun to slow due to ongoing population growth in Tokyo and the high cost of living there. The Tokyo Stock Exchange is Japan's largest stock exchange, and third largest in the world by market capitalization and fourth largest by share turnover (Horticulture statistics team, 2003). Tourism in Tokyo is also a contributor to the economy.

4. Cityscape

Architecture in Tokyo has largely been shaped by Tokyo's history. Twice in recent history has the metropolis been left in ruins: first in the 1923 Great Kanto earthquake and later the extensive firebombing in World War II. Because of this, Tokyo's urban landscape consists mainly of modern and contemporary architecture, and older buildings are scarce (Hidenobu, 1995). Tokyo features many internationally famous forms of modern architecture including Tokyo International Forum, Asahi Beer Hall, Mode Gakuen Cocoon Tower, NTT Docomo Yoyogi Building and Rainbow Bridge. Tokyo also features two distinctive towers: Tokyo Tower and the new Tokyo Skytree which is the tallest tower in Japan and the second tallest structure in the world.

Tokyo also contains numerous parks, shrines, Buddhist temples, Japanese gardens, historical buildings, and related museum. . There are four national parks in Tokyo Prefecture, including the Fuji-Hakone-Izu National Park, which includes all of the Izu Islands. The world's tallest freestanding broadcasting tower Tokyo Sky tree are just a few examples of sightseeing spots full of history and tradition.

5. Population and density

The densely inhabited district in great Tokyo area is shown in figure 3.2 with the source from Ministry of Land, Infrastructure, Transport and Tourism (MLIT).

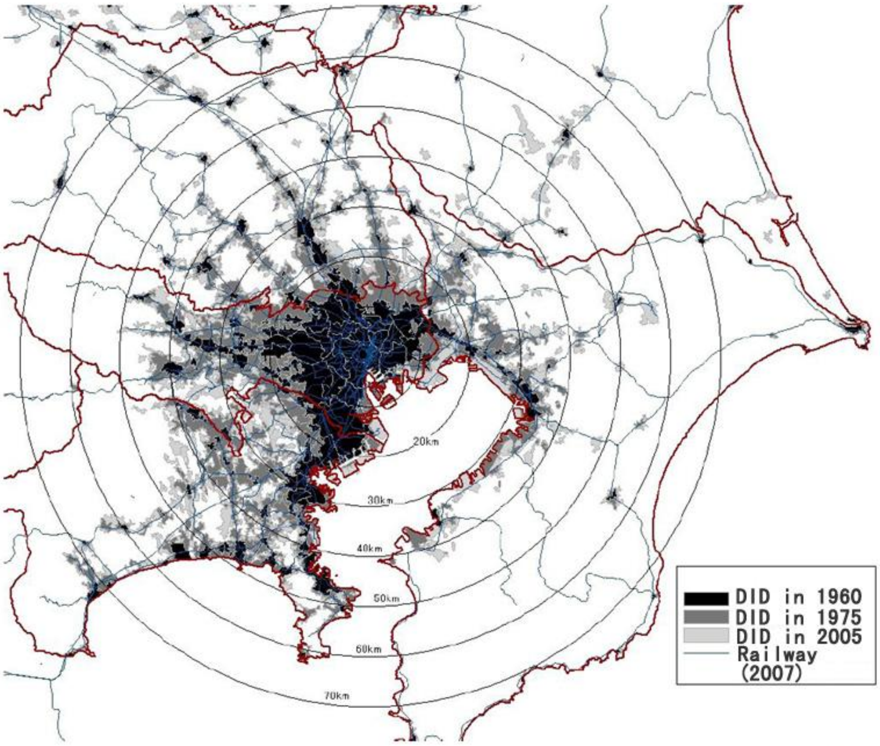


Figure 3. 2 Densely inhabited district (DID) in Great Tokyo Area

Here, we want to explain the meaning of Densely Inhabited Districts. Densely Inhabited

Districts (DID) refers to statistical districts in Japan set in the population census. They are districts which are composed of groups of contiguous population census enumeration districts each of which has a population density of more than 4,000 inhabitants per square kilometer, and the combined population of the contiguous districts exceeds 5,000. However, highly urbanized enumeration districts such as airports, seaports, industrial districts and parks are also included among densely inhabited districts even with small population density. They are used as standards classifying urbanized areas and rural areas and indicating the sizes of urban areas in a narrow sense.

In the figure, the red line is the boundary between prefectures. The dark blue area is approximate to the 23 wards in Tokyo prefecture. By the population census data in 2005, that the population in Japan is 127 million, and the population and the DID population in great Tokyo area (Tokyo, Chiba, Saitama, and Kanagawa) is 38.7 million and 34 million respectively is obtained .According to the definition of DID, we can get a conclusion that there are one- third persons in Japan live in great Tokyo area, and most of the population gathers in the central part of Tokyo.

3.1.2 Brief introduction of Chengdu city

Chengdu is one of the most important economic, transportation, and communication centers in Western China. According to the 2007 Public Appraisal for Best Chinese Cities for Investment, Chengdu was chosen as one of the top ten cities to invest in out of a total of 280 urban canters in China. In 2006, it was named China's 4th-most liveable city by China Daily (Jing, 2006).

1 History

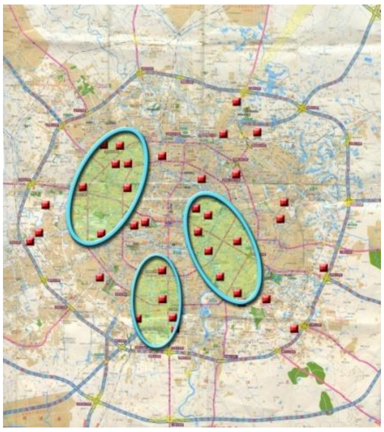
The history of the city can be traced back 2400 years when the first emperor built his capital here and named the city. Through thousands of years its original name has been kept and its position as the capital and as the significant center of politics, commerce and military of the Sichuan area (once called Shu) has remained unchanged. Since the Han (206B.C.-220) and Tang (618-907) Dynasties when its handicraft industry flourished, the place has been famous for its brocades and embroideries. The city was also the place where the bronze culture, an indispensable part of ancient Chinese culture, originated.

2　Climate

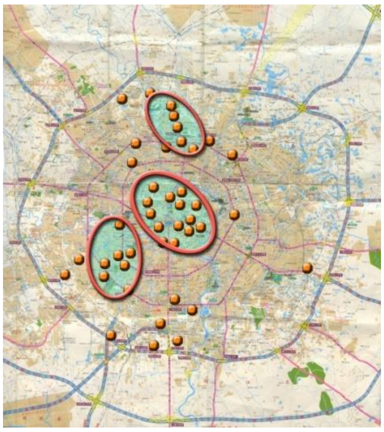
Chengdu has a monsoon influenced humid subtropical climate and is largely mild and humid. It has four distinct seasons, blessed with abundant rainfall, and relieved from both sweltering summers and freezing winters. The summer is hot and humid. Rainfall is common year-round but is the greatest in July and August, with very little of it in the cooler months. Snow is rare but there are a few periods of frost each winter.

3　Geographical distribution of industrial development

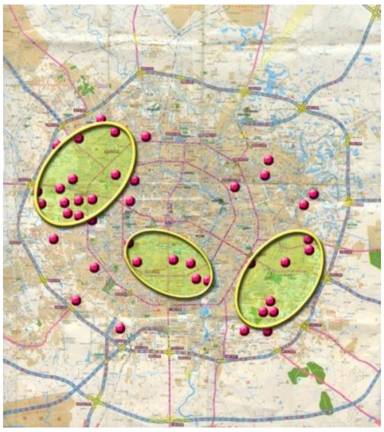
China's state council has designated Chengdu as the country's western center of logistics, commerce, finance, science and technology, as well as a hub of transportation and communication. It is also an important base for manufacturing and agriculture.



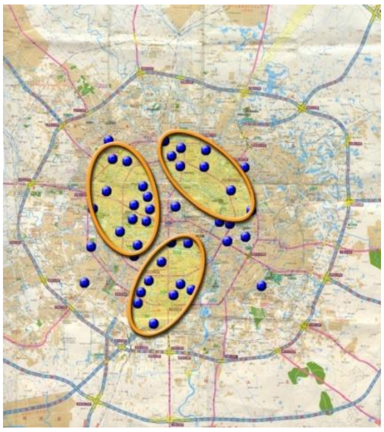
Medical facilities distribution



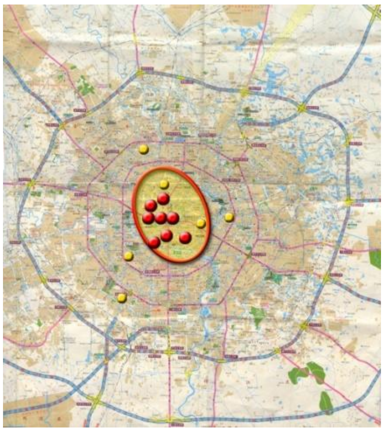
Commercial facilities distribution



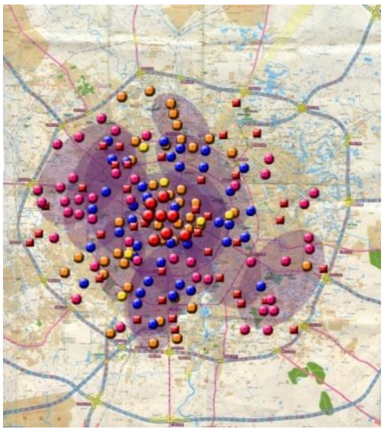
High education institute distribution



Accommodation distribution



Government house distribution



Distribution of combination

Figure 3. 3　Distribution of various main facilities

Figure 3.3 shows the distribution of some main facilities in Chengdu city. It reveals that the main facilities are concentrated in the city centre.

4 Cityscape

Because of the long history and splendid culture, Chengdu features historic places of interest such as the Thatched Cottage of Du Fu, Wuhou Memorial Temple and Wenshu Monastery etc.

Table 3. 1 the characteristic of each group in Yang et al.'s research(2012a)

Leaf	Width of sidewalk		The presence of shop		Pavement		Comfort	Activity
	<3.55	⩾3.55	Not exist	exist	bad	good	mean	mean
1		●	●				3.294	3.147
2		●		●	●		2.294	3.250
3		●		●		●	3.206	3.294
4	●		●				3.412	2.353
5	●			●			2.706	2.941

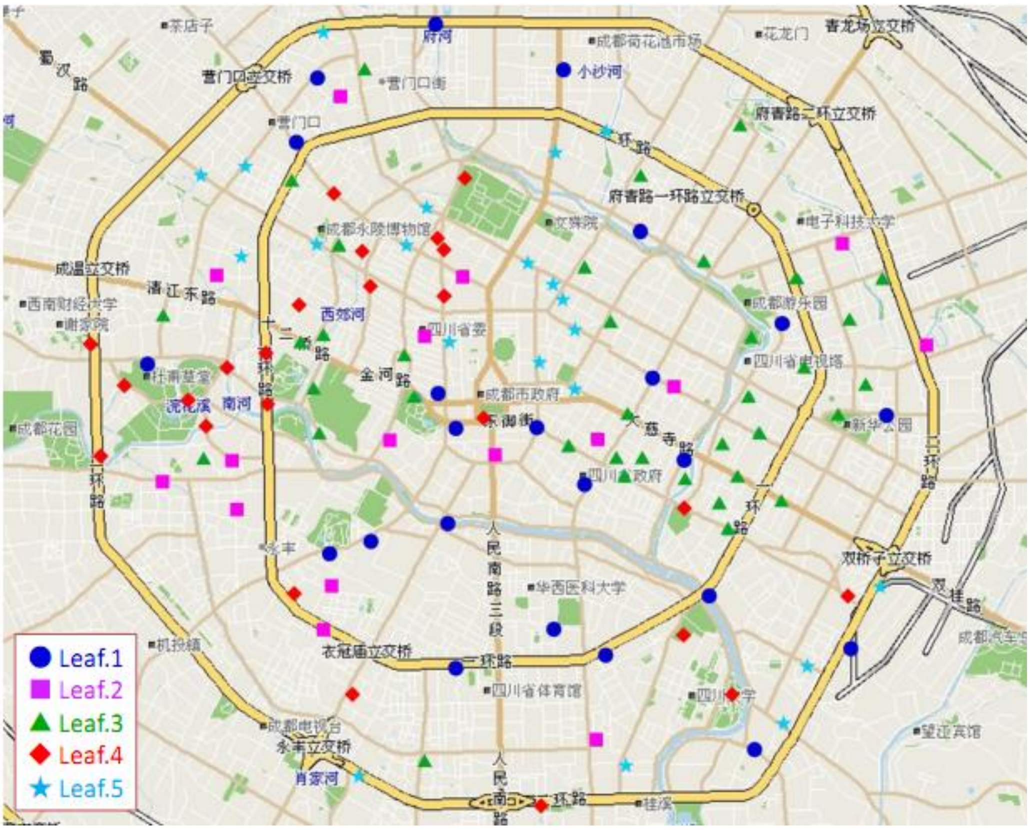


Figure 3. 4 the distribution of each group in Yang et al.'s research (2012a)

Regarding the streetscape in Chengdu city, we can get some hints from Yang et al.'s research. The data shown in Figure 3.4 and Table 3.1 is the result of sidewalk landscape researched by

Yang et al. (2012a). It is clear from figure 3.4 and table 3.1 that the streets in the northwest of Chengdu is in low activity with narrow sidewalk and the streets in the north of Chengdu is not comfortable also with the narrow sidewalk. At the same time, that the active and comfortable sidewalks mainly exist in the east and central part of Chengdu can be revealed.

Figure 3.5 is indicative of distribution of green area in Chengdu. As can be seen from the figure, the greenery is mainly concentrated in the eastern.

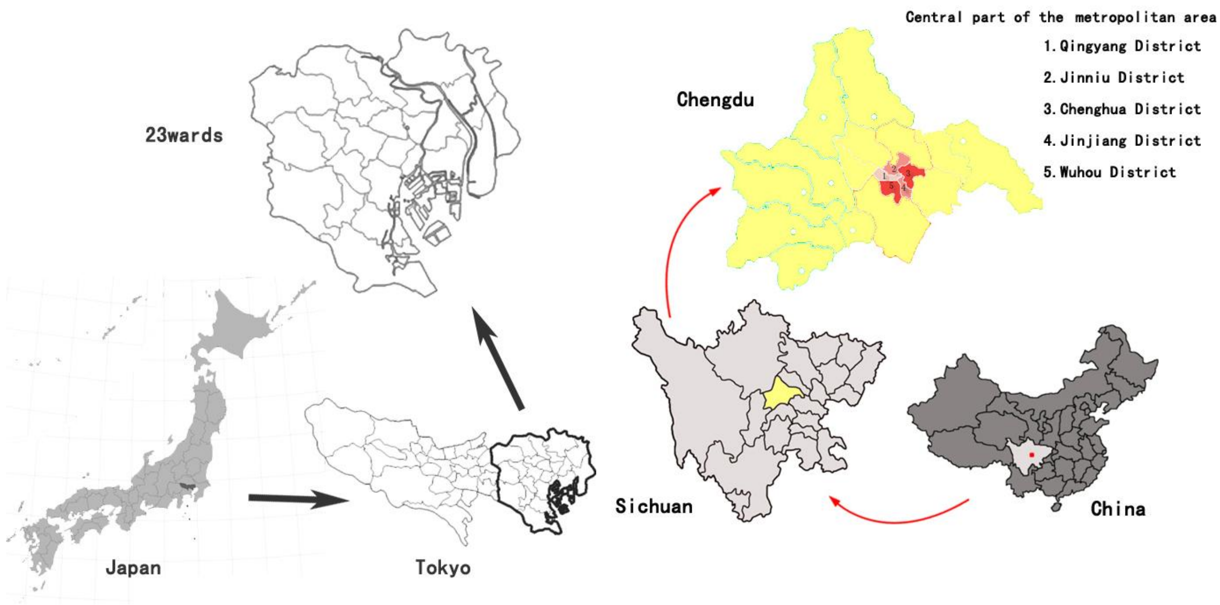
Figure 3. 5 the distribution of green area in Chengdu city

5 Population and density

Chengdu prefecture covers a total area of 12.121 thousand square kilometers with a population of over 14 million. According to the sixth national population census of the People’s Republic of China conducted in 2010, the urban area of Chengdu houses 14,047,625 permanent inhabitants: 7,123,697 within the municipality's nine districts and 6,730,749 in the surrounding region. The population density in Chengdu city is 1159 persons per square kilometer, but in the 5 central districts, the density extremely increases to 11419 persons per square kilometer.

3.1.3 Comparison of two cities

The survey regions are 23 wards in Tokyo city and 5 centre districts in Chengdu city. The location of these regions can be seen in figure 3.6.

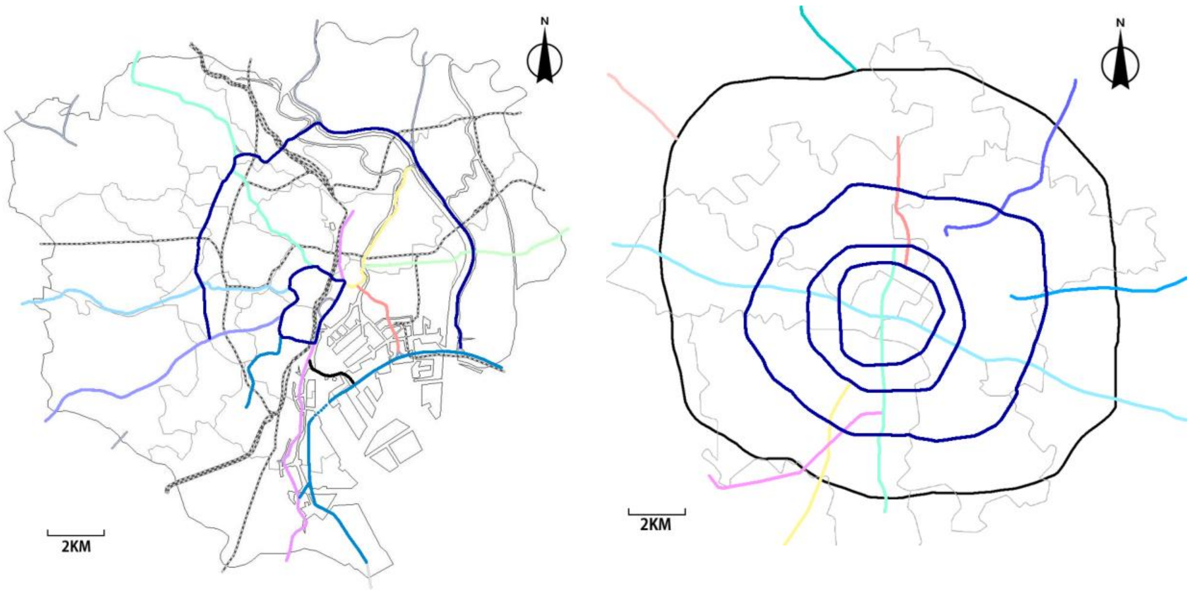


location of survey region in Tokyo city   location of survey region in Chengdu city

Figure 3. 6 Location of survey region in two cities

The reasons for selecting these places are as follows. Chengdu is the two-thousand year old provincial capital of Sichuan province. Similar to other cities in China, there has been a rapid increase in the number of vehicles. In the central part, famous places like Wuhou Memorial temple, Dufu Thatched Cottage, Qingyang temple, which are dotted with historic sites, have also become into one of the major tourism industry. In such areas, the street maintenance overemphasized only in efficiency has a possibility of altering not only the streetscape but also the street. On that account, development with the landscape consideration is required. Thus, also in China, especially Chengdu must perform the street maintenance which noted the street landscape.

In addition, the central part of Chengdu city has a population of approximately 5 million, with a population density of 11419 persons per square kilometers. The only city in Japan with an equivalent population to Chengdu is Tokyo (with about 8.95 million people in Tokyo's 23 wards). Tokyo is the capital of Japan and has been termed as the centre of industry and has the largest economy in Japan. It not only features very high population density, but also suffers from chronic traffic congestion. What is more, the forms of transportation infrastructure in urban areas are similar between Tokyo and Chengdu. A comparison of figure 3.7 (a) and (b) shows that. The road infrastructure of Chengdu is annular with three circular routes. And there is a horizontal main avenue and vertical main road passing through Tianfu square which is located in the centre of Chengdu. Although not perfect, the transportation infrastructure form of Chengdu's central city is similar to the form of Tokyo's inner circular route and central circular route. Besides that, the form of road infrastructure from center toward the outside in Chengdu is similar to the form of Route 1(the Tokyo Metropolitan Expressway) and Route2(the Tokyo Metropolitan Expressway) In a word, the reason that the similarities in the population and transportation infrastructure form between Chengdu and Tokyo motivated to compare Chengdu and Tokyo.



(a) 23 wards of Tokyo Japan
Population: 8.95millions
Area: 621km^2
Population density: 14389persons/ km^2

(b) 5 centre wards of Chengdu China
Population: 4.64millions
Area: 406km^2
Population density: 11419persons/km^2

Figure 3. 7 the comparison of infrastructure between Chengdu and Tokyo

3.1.4 Classification of the street

Generally speaking, street can be classified to 3 types by function, primary distributers, district distributers, and local distributers. The main function of these streets is listed below.

(1) Primary distributer:

Provide for major regional and inter-regional traffic movement and carry large volumes of generally fast moving traffic

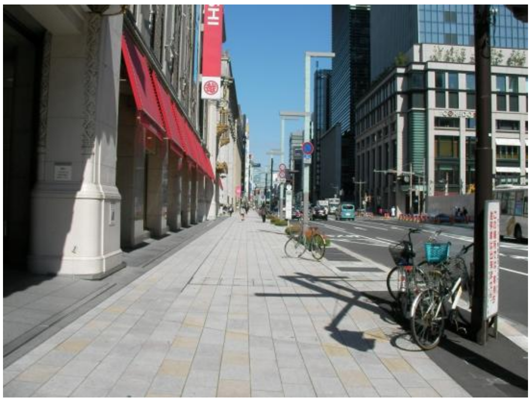
(2) District distributer

Carry traffic between industrial, commercial and residential areas and generally connect to primary distributors

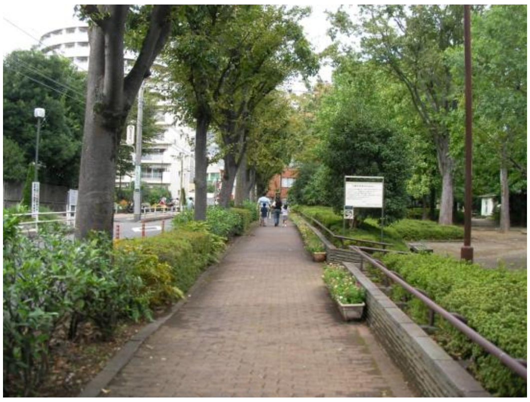
(3) Local distributer

Carry traffic within a cell and link district distributers to access roads

According to the figure 3.8, we can find that in Tokyo and Chengdu city, streets can not only provide the traffic function but also the communication between city dwellers. And it is obvious that the main function of the primary distributers and district distributers is focused on the traffic while the local distributer is mainly emphasized on the community. As a result, in this research, we decide to classify the streets, and survey the streetscape from wide street (primary distributers and district distributers), and narrow street (local distributer) respectively.



Wide street in Tokyo



Narrow street in Tokyo

Wide street in Chengdu

Narrow street in Chengdu

Figure 3. 8 Typical wide and narrow streetscapes in Tokyo and Chengdu

3.2 Formation of the questionnaire

The question in the questionnaire is graded on a five-grade evaluation scale based on the SD method. After examining the connotative meaning of hundreds of items occurred in the previous researches, we identified two major dimensions: *streetscape evaluation*, and *physical situation*. The scale is set up using *polar adjectives* (opposite-meaning terms) at each end. The respondents are asked to rate a streetscape, by putting a mark on one of the 5 spaces along each dimension. In order to obtain the high accurate data, we draw up the questionnaire by a criteria listed below.

1. To avoid fatigue or boring the respondent, do not use more than 30 lines. Using fewer is acceptable.
2. The location of the positive attributes should be varied from left to right. Do not put all the 'good' adjectives on one side, as it might bias the responses.
3. If the questionnaire is conducted with many respondents at once, reverse the items'order of part of the questionnaires.
4. Provide clear instructions for the respondent so that they put their marks in the right place.

The survey required respondents to think about the most impressive wide road and narrow road they knew in their respective cities and fill in the questionnaire accordingly. The locations of the positive attributes are exchanged in turn in different items to avoid putting all the 'good' adjectives on one side, and the locations of items are also changed in different questionnaire paper. At the same time, the maps of survey regions are attached to the questionnaire to avoid the confusion. The sample of the questionnaire can be seen in the appendices. The introduction on the questionnaire of primary and district distributor road and the questionnaire of local distributor road will follow shortly.

3.2.1 Questionnaire of primary and district distributor road

Impressive primary distributor road and district distributor road, with sidewalks and more than 3 lanes, are focused upon here. Dozens of adjective pairs were selected in primary stage. In order to avoid fatigue or boring the respondent, the adjective pairs were reduced to 21 pairs. In figure 3.8, the former 8 items fit the theme of streetscape evaluation. The latter 13 items represent physical situations. The location of the good adjectives and bad adjectives are revised. And the meaning of 1 is poorest, and 5 is the best. Instructions are made. After the questionnaire was created in Japanese and translated in Chinese, it was checked for accuracy of nuance by a native Chinese speaker.

1) Comprehensive evaluation			
Q1：	poor	1 – 2 – 3 – 4 – 5	good
Q2：	uncomfortable	1 – 2 – 3 – 4 – 5	comfortable
2) Individual evaluation			
2a) landscape evaluation			
Q3：	ugly	1 – 2 – 3 – 4 – 5	beautiful
Q4：	inharmonious	1 – 2 – 3 – 4 – 5	harmonious
Q5：	uninteresting	1 – 2 – 3 – 4 – 5	interesting
2b) function evaluation			
Q6：	unapproachable	1 – 2 – 3 – 4 – 5	approachable
Q7：	deserted	1 – 2 – 3 – 4 – 5	bustling
Q8：	hard to walk	1 – 2 – 3 – 4 – 5	easy to walk
3) Physical situation			
3a) road situation			
Q9：	Lot of garbage	1 – 2 – 3 – 4 – 5	no garbage
Q10：	many obstacles	1 – 2 – 3 – 4 – 5	no obstacles
Q11：	poor road surface	1 – 2 – 3 – 4 – 5	good road surface
Q12：	few roadside trees	1 – 2 – 3 – 4 – 5	many roadside trees
3b) landscape・spatial situation			
Q13：	isolated	1 – 2 – 3 – 4 – 5	open
Q14：	ugly architecture	1 – 2 – 3 – 4 – 5	beautiful architecture
Q15：	dense	1 – 2 – 3 – 4 – 5	scattered
3c) utilization situation			
Q16：	noisy	1 – 2 – 3 – 4 – 5	quiet
Q17：	congested	1 – 2 – 3 – 4 – 5	vacant
3d) use situation of architecture			
Q18：	few shops	1 – 2 – 3 – 4 – 5	many shops
Q19：	few residential houses	1 – 2 – 3 – 4 – 5	many residential houses
Q20：	few office buildings	1 – 2 – 3 – 4 – 5	many office buildings
Q21：	few factories	1 – 2 – 3 – 4 – 5	many factories

Figure 3. 9 Content of primary and district distributor road questionnaire

3.2.2 Questionnaire of local distributor road

Impressive local distributor road with sidewalks are focused upon here. In the figure 3.9, the first 4 items below fit the theme of streetscape evaluation. The latter 13 represent physical situation. The same as the questionnaire introduced previously, the location of the good adjectives and bad adjectives are revised. And the meaning of 1 is poorest, and 5 is the best. Rate the impressive local distributor road on each of the following dimensions.

1) Streetscape evaluation			
Q1：	uncomfortable	1 – 2 – 3 – 4 – 5	comfortable
Q2：	ugly	1 – 2 – 3 – 4 – 5	beautiful
Q3：	uninteresting	1 – 2 – 3 – 4 – 5	interesting
Q4：	hard to walk	1 – 2 – 3 – 4 – 5	easy to walk
2) Physical situation			
Q5：	Lot of garbage	1 – 2 – 3 – 4 – 5	no garbage
Q6：	poor sidewalk pavement	1 – 2 – 3 – 4 – 5	good sidewalk pavement
Q7：	many obstacles	1 – 2 – 3 – 4 – 5	no obstacles
Q8：	few roadside trees	1 – 2 – 3 – 4 – 5	many roadside trees
Q9：	isolated	1 – 2 – 3 – 4 – 5	open
Q10：	ugly architecture	1 – 2 – 3 – 4 – 5	beautiful architecture
Q11：	dense	1 – 2 – 3 – 4 – 5	scattered
Q12：	noisy	1 – 2 – 3 – 4 – 5	quiet
Q13：	congested	1 – 2 – 3 – 4 – 5	vacant
Q14：	few shops	1 – 2 – 3 – 4 – 5	many shops
Q15：	few office buildings	1 – 2 – 3 – 4 – 5	many office buildings
Q16：	few residential houses	1 – 2 – 3 – 4 – 5	many residential houses
Q17：	few factories	1 – 2 – 3 – 4 – 5	many factories

Figure 3. 10 Content of local distributor road questionnaire

After the questionnaire was created in Japanese and translated in Chinese, it was checked for accuracy of nuance by a native Chinese speaker.

3.3 Implementation of the questionnaire

Among the questionnaire respondents, 100 graduate students were from the Southwest Jiaotong University in Chengdu and 159 undergraduate students were enrolled in the Faculty of Humanities and Environment at Hosei University, Japan. Both surveys were conducted in August 2011.

In Hosei University, the questionnaire was conducted in the class. The scene of the questionnaire survey can be seen in figure 3.10. 287 Respondents were requested to rate the impressive wide road (includes primary distributor road and district distributor road) and impressive narrow road (local distributor road) in Tokyo 23 wards accordingly. The valid response is 159.

Figure 3. 11 the scene of the questionnaire survey

In Southwest Jiaotong University, as the campus of undergraduate students is in suburb and the campus in urban area houses graduate students, the respondents in Chengdu questionnaire survey are 180 graduate students from the Southwest Jiaotong University. The conduct way of questionnaire survey is face to face and one by one. The valid response is 100.

Chapter 4 Streetscape Evaluation of primary and district distributor roads

In a questionnaire analysis of this kind, it is not rare to have discussions (Shimokawa et al. 2009, and Yang. et al. 2012a, 2012b) about fitness of a regression model. In recent years, ensemble learning, as a statistical method to rapidly improve the fitness of a model has been attracting attention. Ensemble learning is a method of combining multiple models to obtain better predictive performance than it that obtained from any one of the constituent models. In this paper, Breiman's random forests method (Breiman, 2001) – one of the most famous ensemble learning methods – is used. The excellent reported model's prediction accuracy was expected to yield fundamental knowledge about differences and similarities in evaluation of urban streetscape development in Japan and China.

4.1 Overview of statistical analysis

The following provides an overview of statistical analysis in this survey.

1) To reduce the influence of individual differences in the questionnaire, the normalization of each subject was conducted.

$$x^*_{ji} = (x_{ji} - \bar{x}_i)/s_i \quad (4.1)$$

, where points assigned in the *i*th subject's *j*th item in the questionnaire is x_{ji}, and $\bar{x}_i$ is the mean number of points of the *i*th subject. Also, s_i represents the standard deviation of the *i*th subject's points allocations.

2) The median response of each questionnaire was calculated and the difference in points between Tokyo and Chengdu was compared using the Mann-Whitney Wilcoxon test (a non-parametric test of the null hypothesis) which has greater efficiency than the t-test on non-normal distributions.

3) To estimate the evaluation of landscape using factor analysis, a focus was made on

physical characteristics of streetscape (mentioned in section 3.2.2). To adequately compare Japan and China, the same weightings were given to the questionnaire results from Tokyo and Chengdu.

4) The random forests method was used to process the questionnaire results. In addition, variable importance and partial dependencies were analysed to evaluate physical factors that affect evaluation of streetscapes.

4.2 Introduction of random forest method

Random forests are an ensemble learning method for classification and regression that operate by constructing a multitude of decision trees at training time and outputting the class that is the mode of the classes output by individual trees. The algorithm for inducing a random forest was developed by Breiman (2001). It is a substantial modification of bagging that builds a large collection of de-correlated trees, and then averages them. On many problems the performance of random forests is very similar to boosting, and they are simpler to train and tune. As a consequence, random forests are popular, and are implemented in a variety of packages.

1. Outline of random forests

This model is constructed based on combines the B decision trees. Each tree is constructed using a bootstrap samples. In regression problem, the random forest model $f_{\mathrm{RF}}(\boldsymbol{x})$ for estimation of output y, is given by

$$f_{\mathrm{RF}}(\mathbf{x}) = \frac{1}{B}\sum_{b=1}^{B} T_b(\mathbf{x};\boldsymbol{\theta}_b) \tag{4.2}$$

, where $\boldsymbol{x}$ is P predictor variable $\boldsymbol{x}=(x_1,x_2,...,x_P)^{\mathrm{T}}$, and $\boldsymbol{\theta}_b$ is a parameter vector (partitioning variables, and splitting points) of bth tree. The algorithm of constructing trees $T_b(\boldsymbol{x};\boldsymbol{\theta}_b)$ is applied growth process in CART algorithm, under randomly selected m ($< P$) variables at each node to consider for splitting. Given a training set $L= \{\boldsymbol{x}_n, y_n\}$, n=1... N, the random forest procedure is described in Algorithm 4.1.

Algorithm.4.1:The random forest algorithm for regression problem

0 **Input :** B: the number of tree in the forest. m: the number of random predictor variable to select (default P/3)

1 **For** b=1,...,B

a: Generate a bootstrap sample L_b^* of size N by sampling with replacement from the training set L. The nonbootstrap samples for iteration b is called Out-Of-Bag (OOB) samples L_b^{OOB}.

b: Grow a tree model $T_b(\mathbf{x};\hat{\boldsymbol{\theta}}_b)$ using the bootstrap samples L_b^*, randomly selecting at each node in the tree m variables to consider for splitting, until the minimum node size $n_{\min}$.

2 **Next** b

3 **Output:** the estimated random forest model is given by

$$\hat{f}_{\text{RF}}(\mathbf{x}) = \frac{1}{B}\sum_{b=1}^{B} T_b(\mathbf{x};\hat{\boldsymbol{\theta}}_b) .$$

2. Variable importance

The random forests model is constructed so many trees that they are useless for interpretation. In interpretation of estimated random forests model, a descriptive statistics that is often of interest is the variable importance of the respective predictor variables. The variable importance uses the OOB samples to construct a different variable importance measure, apparently to measure the prediction strength of each variable. When the bth tree is grown, the OOB samples are passed down the tree, and the prediction accuracy is recorded. Then the values for the pth variable are randomly permuted in the OOB samples, and the accuracy is again computed. The decrease in accuracy as a result of this permuting is averaged over all trees, and is used as a measure of the importance of variable x_p (Hastie et al., 2009).

3. Partial dependence

For two or more predictor variables, we are difficult to graphical evaluate influences of predictor variables to the random forests model. A useful alternative can sometimes be to view a collection of plots, each one of which shows the partial dependence of the approximation $f_{\mathrm{RF}}(\boldsymbol{x})$ on a selected small subset of the predictor variables (Friedman, 2001).

Consider l ($l<P$) variable $\boldsymbol{x}_S$, indexed by $S \subset \{1,2,...,P\}$. Let C be the complement set, with $S \cup C = \{1,2,...,P\}$. Then, estimated random forest model in principle depend on variables in both subsets $f_{\mathrm{RF}}(\mathbf{x}) = f_{\mathrm{RF}}(\mathbf{x}_S, \mathbf{x}_C)$. The partial dependence of $f_{\mathrm{RF}}(\boldsymbol{x})$ on $\boldsymbol{x}_S$ is defined as

$$f_S(\boldsymbol{x}_s) = \mathrm{E}_{X_c} f_{\mathrm{RF}}(\boldsymbol{x}_S, \boldsymbol{x}_C) \tag{4.3}$$

Given a training set $L=\{\boldsymbol{x}_n, y_n\}$, $n=1,...,N$, the partial dependence function for subset variables $\boldsymbol{x}_S$ is estimated by

$$\bar{f}_S(\boldsymbol{x}_S) = \frac{1}{N}\sum_{n=1}^{N} \hat{f}_{\mathrm{RF}}(\boldsymbol{x}_S, \boldsymbol{x}_{C,i}) \tag{4.4}$$

, where $\{\boldsymbol{x}_{C,1}, \boldsymbol{x}_{C,2},..., \boldsymbol{x}_{C,\mathrm{N}}\}$ are the values of $\boldsymbol{x}_C$ (Hastie et al.2009) .

4.3 Result

4.3.1 Summary of the result

T-Tests are widely used by researchers to compare the average values of a numeric outcome between two groups. If there are doubts about the suitability of the data for the requirements of a t-test, most notably the distribution being non-normal, the Wilcoxon-Mann-Whitney test is often used instead. Wilcoxon-Mann-Whitney test has greater efficiency than the t-test on non-normal distributions, such as a mixture of normal distributions, and it is nearly as efficient as the t-test on normal distributions (Mann and Whitney, 1947).

Normalized questionnaire results for each question were compared using the Mann-Whitney Wilcoxon test and are shown in Table 4.1. Items that were significantly higher for Chengdu than for Tokyo are stated in the questions Q9 (lot of garbage-no garbage)，Q16 (noisy-quiet)，Q17 (congested-vacant)， andQ20 (few office buildings-many-office buildings). In other words, we can say that Chengdu had a strong tendency toward the right side of the response range in comparison with Tokyo. In regard to the item mentioned in Q9, the tendency may have been influenced by street cleaners' very frequent sweeping of main roads of Chengdu's center. In regards to the item mentioned in Q16, the tendency may be a result of the presence of noisy advertising vehicles in the commercial area of Tokyo, but rarely in Chengdu, hence making Chengdu residents sensitive to noise. In regard to the item mentioned in Q17, the number of roadways does not necessarily correlate with the width of sidewalks. However, in Chengdu, the sidewalk along the main road is very wide and is not liable to cause a feeling of congestion. In regard to the item mentioned in Q20, the tendency may be a result of the presence of high office buildings in Chengdu's centre with loose height restriction.

Table 4. 1 Comparison of the items between Tokyo and Chengdu

(is represents significant item, *p<0.05, **<0.01, ***<0.001)

		Tokyo	Chengdu	p value	
Q1	poor - good	0.612	0.605	0.937	
Q2	uncomfortable - comfortable	0.299	0.194	0.243	
Q3	ugly - beautiful	0.236	0.332	0.290	
Q4	inharmonious - harmonious	0.208	0.104	0.362	
Q5	uninteresting - interesting	0.180	-0.152	0.001	**
Q6	unapproachable - approachable	0.076	0.053	0.839	
Q7	deserted - bustling	0.891	0.524	0.003	**
Q8	hard to walk - easy to walk	0.115	0.062	0.625	
Q9	lot of garbage - no garbage	-0.075	0.428	<0.001	***
Q10	many obstacles - no obstacles	0.719	0.203	<0.001	***
Q11	poor road surface- good road surface	-0.010	-0.032	0.831	
Q12	few roadside trees - many roadside trees	0.037	-0.035	0.539	
Q13	isolated - open	0.493	0.371	0.237	
Q14	ugly architecture - beautiful architecture	0.488	0.204	0.009	**
Q15	dense - scattered	-0.647	-0.562	0.439	
Q16	noisy - quiet	-0.863	-0.620	0.011	*
Q17	congested - vacant	-0.761	-0.400	0.001	**
Q18	few shops - many shops	0.298	0.217	0.579	
Q19	few residential houses - many residential houses	0.153	-0.131	0.012	**
Q20	few office buildings - many office buildings	-1.035	-0.235	<0.001	***
Q21	few factories - many factories	0.813	0.875	0.637	

Items that were scored higher in Tokyo than in Chengdu are given in the following questions

Q5 (uninteresting-interesting)，Q7 (deserted-bustling)，Q10 (many obstacles-no obstacles)，Q14 (ugly architecture-beautiful architecture)， and Q19 (few residential houses-many residential houses). It means that Tokyo is much more interesting and bustling than Chengdu. The architecture is more beautiful in Tokyo than in Chengdu. And the quantity of residential houses is bigger and the obstacles are less in Tokyo’s centre. Tokyo is an international metropolis. Many foreigners from worldwide make Tokyo become a multicultural city. As a result, many streets are active and interesting. Besides that, land in japan is privately-owned, so in the centre of Tokyo, there still remain many residential houses. While in Chengdu, in order to build more departments and hotels, residential houses are mainly migrated to the edge of city urban. From the situation mentioned above, it is easy to understand the results obtained from the table 4.1.

4.3.2 Estimation of factors affecting evaluation of streetscapes

In many areas of psychology and other disciplines in the behavioural sciences, it is often not possible to measure directly the concepts of primary interest. Two obvious examples are intelligence and social class. In such case the researcher is forced to examine the concepts indirectly by collecting information on variables that can be measured or observed directly, and which can also realistically be assumed to be indicators, in some sense, of the concepts of real interest (Everitt, 2004). In the landscape field, factor analysis is often be used to explore the latent structure as mentioned in section 2.5.

The basis of factor analysis is a regression model linking the manifest variables to a set of unobserved (and unobservable) latent variables. In essence the model assumes that the observed relationships between the manifest variables (as measured by their covariances or correlations) are a result of the relationships of these variables to the latent variables (Everitt, 2004). Here, we estimate the factors affecting evaluation of streetscapes by using factor analysis. Because the goal of the study was to explore the physical factors affecting the evaluation derived from streetscapes and consider similarities and differences between Tokyo and Chengdu, the same factors were considered for both cities. The data from both Tokyo and Chengdu was analyzed using factor analysis of both comprehensive evaluation items (Q1–Q2) and individual evaluation items (Q3–Q8). In addition, the maximum likelihood estimation was used to estimate the parameters in factor analysis. The minimum number of factors was decided when the p-value of the good-of-fit test became insignificant. Varimax factor rotation was used and the factor score was calculated using the Bartlett method.

Table 4. 2 Factor loadings for evaluation of streetscape

(■ expresses the item that the factor loading is bigger than 0.20)

		The 1st factor (comfort)	The 2nd factor (beauty)	The 3rd factor (activity)
Q1	poor - good	0.288	0.133	-0.203
Q2	uncomfortable - comfortable	0.994	0.073	0.050
Q3	ugly - beautiful	0.005	0.963	-0.162
Q4	inharmonious - harmonious	0.064	0.229	0.128
Q5	uninteresting - interesting	-0.004	0.024	0.385
Q7	deserted - bustling	-0.180	-0.010	0.619
Q8	hard to walk - easy to walk	0.005	0.098	-0.240
Q6	unapproachable - approachable	-0.077	-0.122	0.073
	Contribution	0.139	0.128	0.09

Three factors were extracted (p-value = 0.518). The factor loadings are illustrated in Table 4.2. For the 1st factor, the factor loading of the item given in Q2 (comfortable–uncomfortable) was extremely high and that of the item given in Q1 (good–poor) was the next highest. Therefore, comfort was termed as the 1st factor. The factor loading of the item given in Q7 (deserted-bustling) had a negative value, which means "bustle" and "comfort" have a contradictive relationship. This relationship agrees with Yang et al.'s research (2012a, 2012b). For the 2nd factor, the factor loading of the item given in Q3 (ugly-beautiful) was extremely high, and the second highest item was given in Q4 (inharmonious-harmonious). Accordingly, beauty was termed as the 2nd factor. For the 3rd factor, the item given in Q7 (deserted-bustling) had the largest factor loading, and the second largest was given in Q5 (uninteresting-interesting), whereas items such as "hard to walk-easy to walk," "ugly-beautiful" and "poor-good" had negative values. Therefore, activity was termed as the 3rd factor. The three factors together have a cumulative contribution of 35.7%.

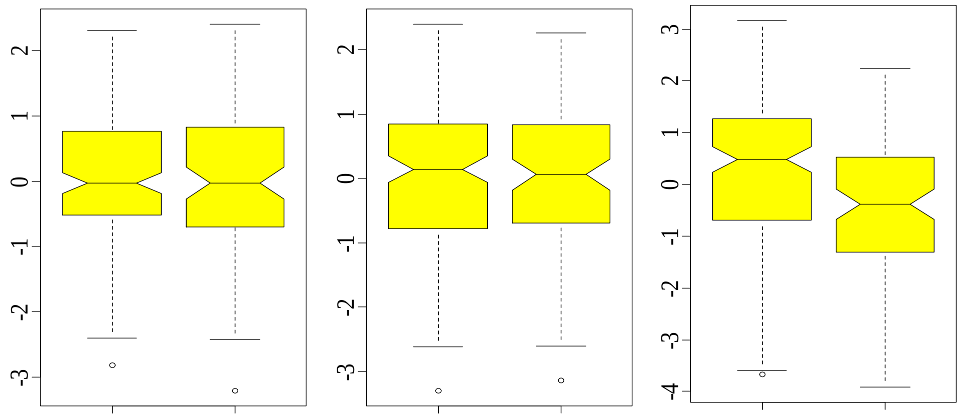


Figure 4. 1 The box-whisker plots of factor scores between Tokyo and Chengdu
(p-value calculated using the Mann-Whitney Wilcoxon test)

Figure 4.1 provides a comparison of factor scores between Tokyo and Chengdu through a notched box plot with the Wilcoxon test. There is no significant difference between comfort and beauty factor scores between Tokyo and Chengdu (comfort's p-value = 0.724， beauty's p-value = 0.929). However, for the activity factor, the factor score in Tokyo was significantly higher than that in Chengdu (in other words, it hints that Tokyo is much more active than Chengdu). In Table 4.1, it can be seen in Q5 (uninteresting-interesting) and Q7 (deserted-bustling) that the factor loading in Tokyo is significantly higher than that in Chengdu. This is considered to be the cause for differences in factor scores.

4.3.3 Exploration of physical factors affecting evaluation of streetscape

The three cognitive characteristics (comfort, beauty, and activity) obtained in section 4.3.2 were used as dependent variables, and the 13 physical factors from items given in Q9–Q21 were made independent variables. The random forests method was applied to the data for both cities on this basis. In this method, the number of trees is selected when the out-of-bag estimator of the error sum of squares is the minimum, under a condition where the maximum number of trees is 1000.

The goal of the study was to answer the following questions. (1) What are the physical factors that affect evaluation of streetscapes? (2) Are there differences in the physical factors between Chengdu and Tokyo that affect evaluation of streetscapes? (3) If there are differences, how do the evaluations in Tokyo and Chengdu change according to the changes in physical factors?

1. Exploration of the factors affecting comfort

The variable importances for comfort are shown in Table 4.3. Variable importance is a relative statistical value that is given when independent variables (in this case, the physical factors) affect the dependent variable (comfort) under the presumption of the random forests model and the variable importance that affects the dependent variable most is set to 100 .

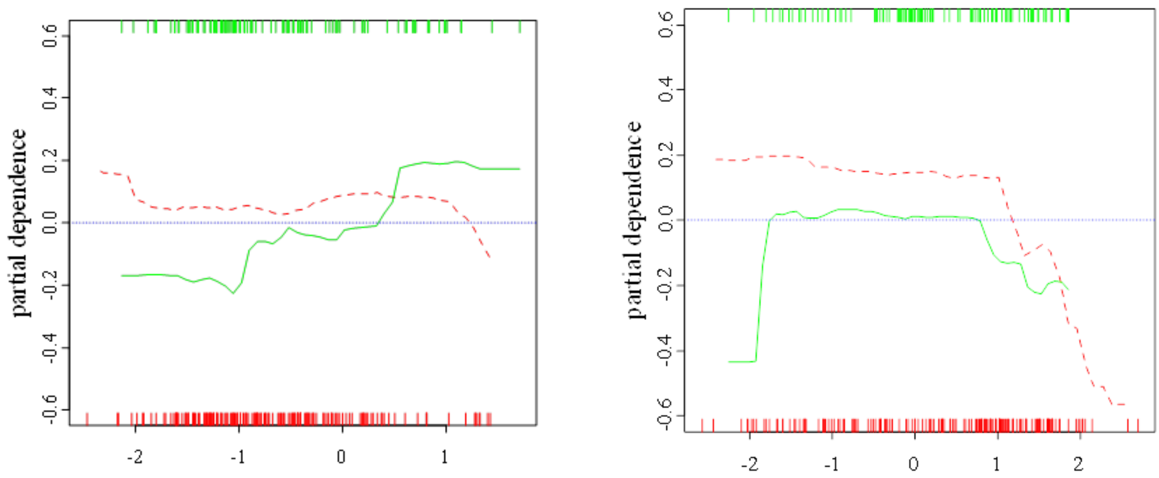
Table 4. 3 Variable importances for comfort

(■variable importance≧90，■variable importance≧80，
■difference of variable importance≧30，■difference of variable importance≧20)

		Tokyo	Chengdu	Tokyo-Chengdu
Q9	lot garbage — no garbage	43.3	52.2	-8.9
Q10	many obstacles — no obstacles	83.3	77.4	5.9
Q11	poor road surface — good road surface	72.9	75.4	-2.5
Q12	few roadside trees— many roadside trees	63.0	80.1	-17.1
Q13	isolated — open	72.7	80.3	-7.6
Q14	ugly architecture — beautiful architecture	53.8	81.9	-28.1
Q15	dense — scattered	55.0	100.0	-45.0
Q16	noisy — quiet	59.0	47.8	11.2
Q17	congested — vacant	51.9	64.7	-12.8
Q18	few shops — many shops	100.0	87.9	12.1
Q19	few residential houses — many residential house	38.0	50.0	-12.0
Q20	few office buildings — many office buildings	62.0	50.9	11.1
Q21	few factories — many factories	74.9	74.4	0.5

In the Tokyo survey, the highest variable importance was given to the item mentioned in Q18 (few shops-many shops). The same item’s variable importance was 87.9 in the Chengdu survey, which made it clear that it was also important for Chengdu’s streetscape comfort. The variable importance of the item given in Q10 (many obstacles-no obstacles) was 83.3 for Tokyo, which made it second item with respect to variable importance.

In the Chengdu survey, the highest variable importance occurred for the item given in Q15 (dense-scattered) with a variable importance of 55.0 in the Tokyo survey, which is not very high. The variable importances of the items in Q13 (isolated-open) and Q14 (ugly architecture-beautiful architecture) were also high. Therefore, it is suggested that among the physical factors for Chengdu, the comfort of streetscapes was particularly strongly influenced by landscape and spatial situation.



← dense scattered → ← few many →

(a) Q15: dense - scattered (b)Q18: few shops - many shops

Figure 4. 2 The partial dependencies on the comfort

(red: Tokyo, green: Chengdu)

Figure 4.2 shown above expresses the partial dependencies for the items which had a variable importance of more than 90 in either Tokyo and Chengdu, or when the absolute value of the difference between Tokyo and Chengdu was larger than 30. The full green line represents Chengdu and the dashed red line represents Tokyo. The horizontal blue line is the datum of 0. The lug in green at top of the graph represents the observed values in Chengdu and red lug at the bottom expresses those observed in Tokyo. The degree of partial dependence indicates how independent variable (i.e., the physical factor) affects the dependent variable (i.e., comfort) under presumptions of the random forests model. Figure 4.2(a) shows that the degree of partial dependence of item in Q15 (dense-scattered) with comfort tends to increase when it becomes more scattered in Chengdu. In contrast, in Tokyo, although a downward tendency is expected at the right end of the graph, because there are few lugs, it is possible that there is over-fitting. From Figure 4.2(b) the following can be observed. Considering the item in Q18 (few shops-many shops), comfort tends to decrease with an increase in the quantity of shops in both Tokyo and Chengdu. Here, although the sharp reduction at the right side of the graph in Chengdu is expected, because the number of lug is only 1, there is a possibility of over-fitting. For that reason, it is considered that the change should not be interpreted.

Therefore, it is suggested that the existence of shops should strongly influence the evaluation of comfort in both Tokyo and Chengdu and comfort should decrease if the quantity of shops increases. Furthermore, the tendency observed in Chengdu states that more scattered the streetscape are, the better the comfort becomes.

2. Exploration of the factors affecting beauty

The variable importances for beauty are shown in Table 4.4.

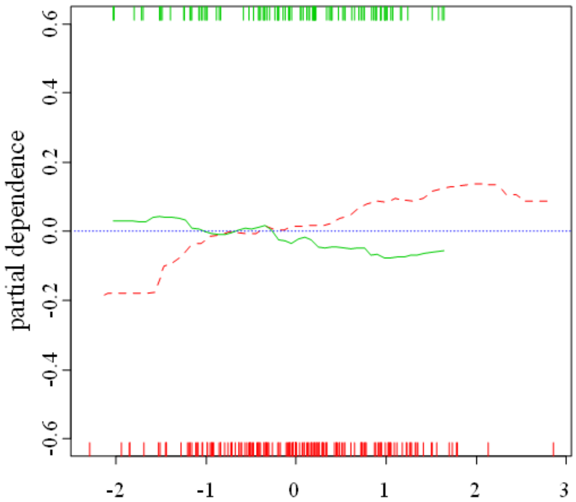
Table 4. 4 Variable importances for beauty

(■variable importance≧90, ■variable importance≧80, ■difference of variable importance≧30, ■difference of variable importance≧20)

		Tokyo	Chengdu	Tokyo-Chengdu
Q9	lot garbage — no garbage	56.5	50.6	5.9
Q10	many obstacles — no obstacles	57.4	56.2	1.2
Q11	poor road surface — good road surface	68.9	43.7	25.2
Q12	few roadside trees— many roadside trees	71.9	38.7	33.2
Q13	isolated — open	63.3	38.0	25.3
Q14	ugly architecture — beautiful architecture	78.7	51.6	27.1
Q15	dense — scattered	100.0	100.0	0.0
Q16	noisy — quiet	64.5	35.0	29.5
Q17	congested — vacant	82.4	58.9	23.5
Q18	few shops — many shops	53.2	46.7	6.5
Q19	few residential houses — many residential house	99.4	49.5	49.9
Q20	few office buildings — many office buildings	89.6	48.2	41.4
Q21	few factories — many factories	74.8	42.6	32.2

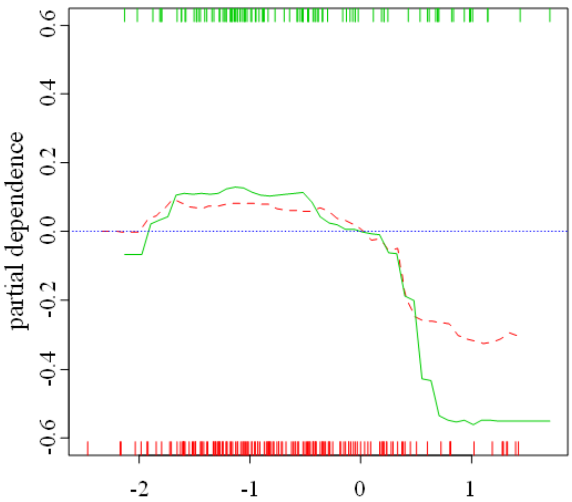
The highest variable importance was given to the item given in Q15 (dense-scattered) for both Tokyo and Chengdu. The variable importances of items given in Q19 (few residential houses-many residential houses), Q20 (few office buildings-many office buildings), and Q17 (congested-vacant) were high. The variable importance of the item given in Q21 (few factories-many factories) for Tokyo was not very high. But it was 32.2 points higher than that for Chengdu. At the same time, the difference values of items between Tokyo and Chengdu in the Q19 (few residential houses-many residential houses) and Q20 (few office buildings-many office buildings) are both larger than 30. Therefore, the influence of building use on beauty is bigger in Tokyo than Chengdu. In contrast, the effect of item in Q15 (dense-scattered) in Chengdu is striking. The variable importance of the item in Q12 (few roadside trees-many roadside trees) for Tokyo was 33.2 points higher than that for Chengdu.

Figure 4.3 shows the degrees of partial dependence on items where the variable importance was more than 90 for either Tokyo and Chengdu or where the absolute value of the difference between the variable importances for Tokyo and Chengdu was larger than 30. The full green line represents Chengdu and the dashed red line represents Tokyo. The horizontal blue line is the datum of 0. The lug in green at top of the graph represents the observed values in Chengdu and red lug at the bottom expresses those observed in Tokyo. Figure 4.3(a) shows that with respect to item (Q12：few roadside trees-many roadside trees), beauty tended to increase with an increase in the quantity of roadside trees for Tokyo, while there was no pronounced increase tendency for Chengdu. This may be due to the fact that in Chengdu, roadside trees are planted along almost all main roads but in Tokyo this only occurs sometimes. In relation to the item in Q15 (dense-scattered), beauty tended to reduce rapidly when density became lower for both Tokyo and Chengdu. In Figure 4.3(b), it can be seen that the reduction was more dramatic in Tokyo than in Chengdu. In this survey, the focus was on the main roads in urban areas. In such areas, roads with a scattered impression may have an ugly appearance. For the item in Q19 (few residential houses-many residential houses), beauty tended to reduce with an increase in the quantity of residential houses in Tokyo. For Chengdu, an increasing trend near zero can be observed, which means that even if the quantity of residential houses decreases, the level of beauty will not change, and the level of beauty will rise with an increase in the quantity of residential houses. The reason may be that in Tokyo, many residential areas along the main road are similar to those at downtown, while in Chengdu, even if residential areas are along the main road, they can be of high quality. To sum up, the different partial independencies may be affected by the different residential situations in Tokyo and Chengdu. In Tokyo, although the partial independence of the item in Q20 (few office buildings-many office buildings) tends to decrease rapidly toward the right side of the graph, it is appropriate to regard this as overfitting because there is almost no lug. Apart from that occurrence, no remarkable change can be observed. For partial independence of the item in Q21 (few factories-many factories), beauty tended to decrease when the quantity of factories became larger for both Tokyo and Chengdu. The reduction tendency was marked high for Tokyo than for Chengdu.



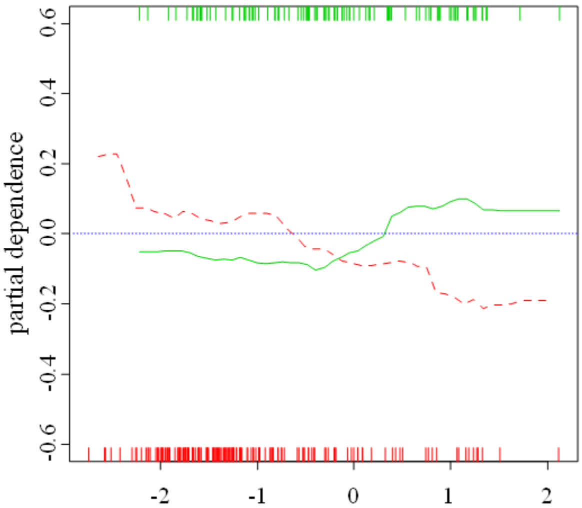
← few many →

(a) Q12 few roadside trees - many roadside trees



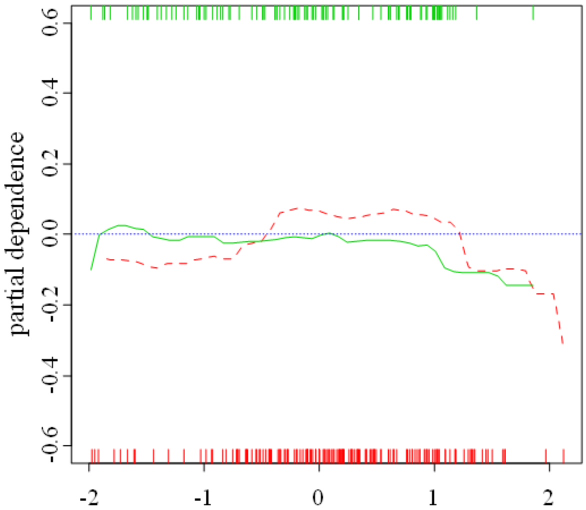
← dense scattered →

(b) Q15 dense - scattered



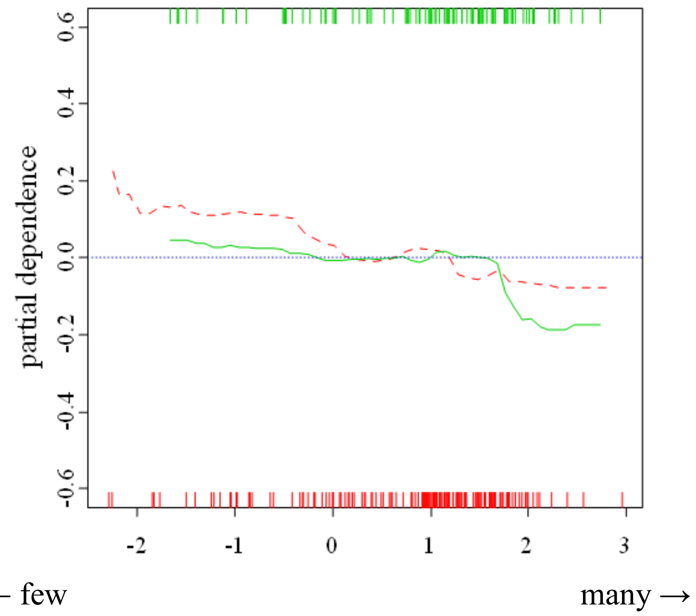
← few many →

(c) Q19 few residential house –many residential house



← few many →

(d) Q20 few office buildings – many office buildings



(e)Q21: few factories - many factories

Figure 4. 3 The partial dependencies on the beauty

(red: Tokyo, green: Chengdu)

3. Exploration of the factors affecting activity

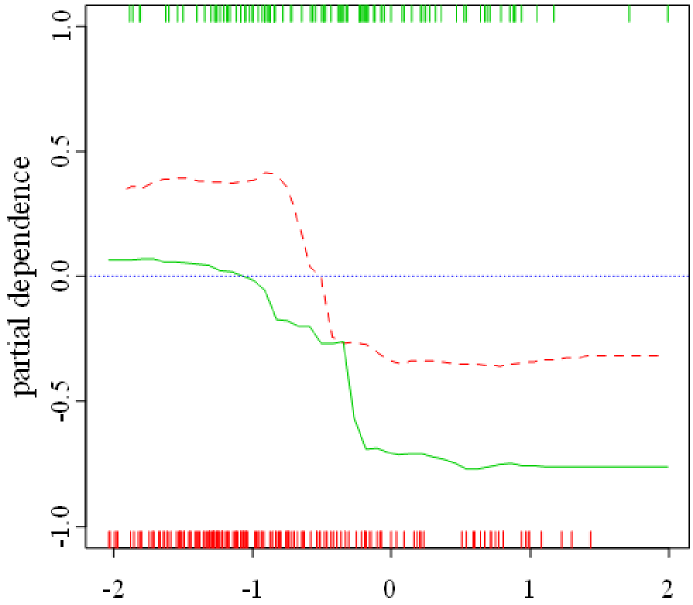
The variable importances for activity are shown in Table 4.5.

Table 4. 5 Variable importances for activity

(■variable importance≧90，■variable importance≧80，■difference of variable importance ≧30，■difference of variable importance≧20)

	Tokyo	Chengdu	Tokyo-Chengdu
Q9 lot garbage - no garbage	54.2	46.4	7.8
Q10 many obstacles - no obstacles	49.7	35.7	14.0
Q11 poor road surface — good road surface	18.2	25.7	-7.5
Q12 few roadside trees- many roadside trees	23.2	52.7	-29.5
Q13 isolated - open	20.6	31.4	-10.8
Q14 ugly architecture - beautiful architecture	22.4	30.6	-8.2
Q15 dense - scattered	59.0	52.8	6.2
Q16 noisy - quiet	51.8	53.7	-1.9
Q17 congested - vacant	100.0	100.0	0.0
Q18 few shops - many shops	58.2	29.4	28.8
Q19 few residential houses - many residential house	22.7	33.6	-10.9
Q20 few office buildings - many office buildings	20.7	48.2	-27.5
Q21 few factories - many factories	26.0	52.7	-26.7

The highest variable importance was given to the item in Q17 (congestion-vacant) for both Tokyo and Chengdu. The other physical factors hardly affected activity.



← congestion vacant→

Q17: congestion- vacant

Figure 4. 4 The partial dependencies on the activity

(red: Tokyo, green: Chengdu)

Figure 4.4 shows degrees of partial dependence on items where the variable importance was more than 90 for either Tokyo and Chengdu, or where the absolute value of the difference between the variable importances for Tokyo and Chengdu was larger than 30. The full green line represents Chengdu and the dashed red line represents Tokyo. The horizontal blue line is the datum of 0. The lug in green at top of the graph represents the observed values in Chengdu and red lug at the bottom expresses those observed in Tokyo. For the item given in Q17 (congestion-vacant), a rapid downward tendency was shown as the road became vacant for both Tokyo and Chengdu. The value of partial independence was higher for Tokyo than for Chengdu. Figure 4.1(c) shows that activity for Tokyo is significantly higher than Chengdu. Therefore, it can be inferred that the magnitude of item in Q17 (congestion-vacant) led to difference in activity.

4.4 Summary

In this chapter, using a questionnaire, the effect of similarities and differences in the importance of physical factors on the evaluation of urban main road (primary and district distributor roads) streetscapes in both Japan and China was explored. The study areas were chosen to be Tokyo 23 wards in Japan and Chengdu 5 central districts in China, as they were considered similar enough and could be compared. The results are summarized as follows:

1. The three chief factors affecting perception of streetscapes were determined as comfort, beauty, and activity. These factors were also extracted in the experiments by Kitamura (1976) and the same trend has been apparent in other researches.

2. Out of the three factors, the activity score of Tokyo was significantly higher than Chengdu.

3. The number of shops strongly influenced the evaluation of comfort for both Tokyo and Chengdu. Comfort plummeted in areas with many shops. Density had a strong effect on comfort in Chengdu, low density increases comfort. It was suggested that for Chengdu, comfort of streetscapes is strongly influenced by landscape and spatial situation.

4. For beauty, the density had the strongest influence in both Tokyo and Chengdu, beauty reduced heavily at great scattering. An increase in the quantity of houses decreased the level of beauty in Tokyo but increased in Chengdu. The impact of building usage on beauty was stronger in Tokyo than in Chengdu.

5. For activity, the congestion of streets had the strongest influence for both Tokyo and Chengdu, with decreasing activity, streets become vacant.

Chapter 5 Streetscape evaluation of local distributor roads

In this chapter, the data of questionnaire survey on local distributor road will be analysed. In the survey, the traffic lane of associable road was required to less than 2 lanes and with sidewalk.

5.1 Overview of statistical analysis

The following provides an overview of statistical analysis in this survey.

1) The median response of each questionnaire was calculated and the difference in points between Tokyo and Chengdu was compared using the Mann-Whitney Wilcoxon test (a non-parametric test of the null hypothesis) which has greater efficiency than the t-test on non-normal distributions.

2) The correlations in all items were calculated using spearman's rank correlation coefficient. To adequately compare Japan and China, the same weightings were given to the questionnaire results from Tokyo and Chengdu.

3) The conditional inference trees method was used to process the questionnaire results. In addition, production rule and mean value of each terminative node were analysed to evaluate physical factors that affect evaluation of streetscapes. At the same time, investigation region was added to explore the interaction from region×physical characteristic that is the regional physical characteristic.

5.2 Introduction of conditional inference trees method

Conditional inference trees estimate a regression relationship by binary recursive partitioning in a conditional inference framework. It is generally applicable to regression problems with arbitrary measurement scale of responses and covariates (Hothorn et al., 2006). Roughly, the algorithm works as follows:

1) Test the global null hypothesis of independence between any of the input variables and the response (which may be multivariate as well). Stop if this hypothesis cannot be rejected. Otherwise select the input variable with strongest association to the response. This association is measured by a p-value corresponding to a test for the partial null hypothesis of a single input variable and the response.

2) Implement a binary split in the selected input variable.

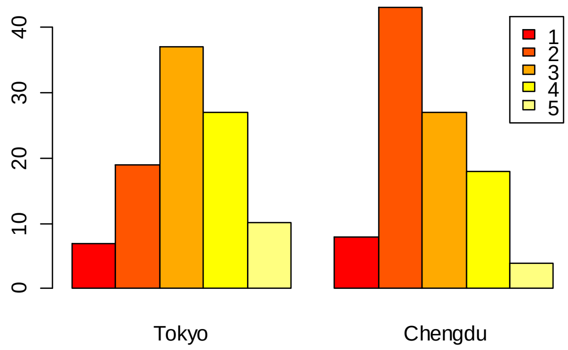
3) Recursively repeats steps 1) and 2).

The implementation utilizes a unified framework for conditional inference, or permutation tests, developed by Strasser and Weber (1999). The stop criterion in step 1) is either based on multiplicity adjusted p-values (test type = "Bonferroni" or test type = "MonteCarlo" in ctree_control) or on the univariate p-values (test type = "Univariate"). In both cases, the criterion is maximized, i.e., 1 - p-value is used. A split is implemented when the criterion exceeds the value given by mincriterion as specified in ctree_control. For example, when mincriterion = 0.95, the p-value must be smaller than 0.05 in order to split this node. This statistical approach ensures that the right sized tree is grown and no form of pruning or cross-validation or whatsoever is needed. The selection of the input variable to split in is based on the univariate p-values avoiding a variable selection bias towards input variables with many possible cut points.

5.3 Totalled results of questionnaire

After counting up the number of local distributor road mentioned in the survey, it is found that in Tokyo's survey, the associable roads were concentrated in the vicinity of the Hosei University such as Kagurazaka Street, Iidabashi area, and the percentage was up to 50.3%. The situation was the same in Chengdu, 58% of the mentioned roads was around the Southwest Jiaotong University. Therefore, we can say that, both in Tokyo and Chengdu, most of the respondents associated the roads around their campus. (Refer to the appendix for the photo of streetscape around the university in Tokyo and Chengdu)

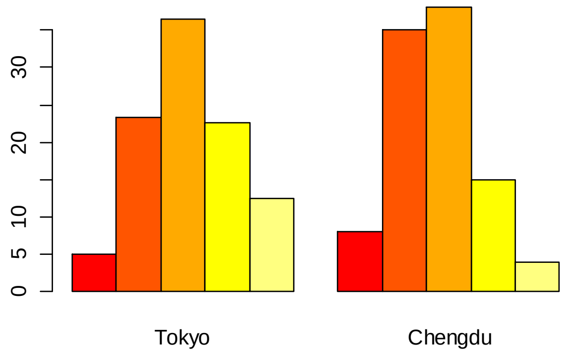
Figure 5.1 is a summary for the four items of streetscape evaluation. The mean value of the whole, Tokyo and Chengdu is shown. And the p-value of the evaluation result of Tokyo and Chengdu by Mann-Whitney Wilcoxon test is also shown. The significant differences were found for all items from the p-value.



Mean=3.14 Mean=2.67

(a) Comfort

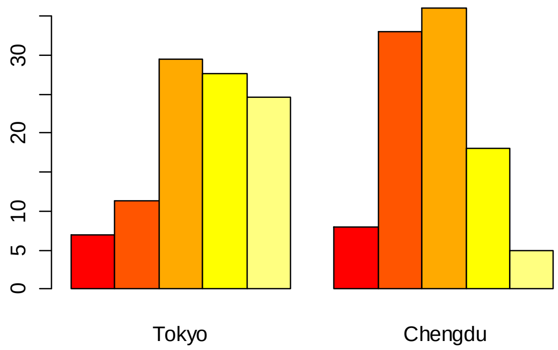
The whole: 2.96 p≤0.001***



Mean=3.14 Mean=2.72

(b) Beauty

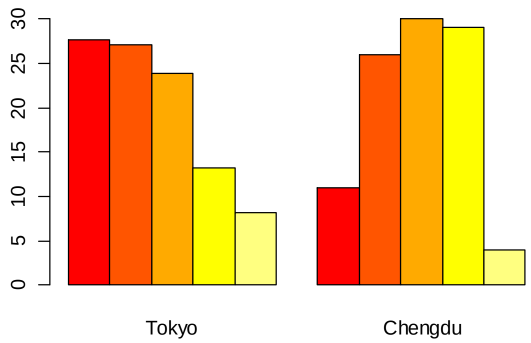
The whole: 2.98 p=0.002**



Mean=3.52 Mean=2.79

(c) Affinity

The whole: 3.24 p≤0.001***



Mean=2.47 Mean=2.89

(d) The ease of walking

The whole: 2.63 p=0.003**

Figure 5. 1 Summary of streetscape evaluation items

(Comfort (Q1), Beauty (Q2), Affinity (Q3), Ease of walking (Q4))

It is clear that the mean value of item in Q1 (comfort), Q2 (beauty), and Q3 (affinity) in Tokyo is higher than in Chengdu. The mean value of item in Q4 (ease of walking) is 2.89 in Chengdu which is larger than in Tokyo. In other words, as for the perceptual item (qualitative item), much more have been satisfied in Tokyo and as for the functional item (quantitative item), more have been satisfied in Chengdu. Especially, the most frequent value of item in Q1 (comfort) is 2 in Chengdu. It hints that there are many complaints from respondents. On the other hand, the most frequent value of the item in Q4 (ease of walking) in Tokyo is 1, and the second frequent value is 2. Therefore, it is considered that difference exists in the streetscape between Tokyo and Chengdu.

The table 5.1 shows the spearman's rank correlation coefficient between streetscape evaluation items. The value of correlation coefficient between items in Q1 (comfort) and in Q2 (beauty) is the highest, 0.50. Additionally, we can know that the item in Q1 (comfort) has the correlation coefficient higher than 0.4 with the other 3 items in Q2, Q3, Q4. That is to say, the item, comfort, is synthetic evaluation measure connected with other factors. As discussed earlier in this chapter, the tendency of mean value of functional item in Q4 (ease of walking) is different from the other three items in Q1, Q2, and Q3 between Tokyo and Chengdu. A point to notice is that the correlation coefficient between item 'ease of walking' and item 'comfort' is 0.40. The correlation coefficient between item 'ease of walking' and item 'beauty' is also not low, reaches to 0.36. Therefore, it is beyond doubt that perceptual evaluation items in Q1, Q2, and Q3 are not uncorrelated with functional evaluation items in Q4.

Table 5. 1 Spearman's rank correlation coefficient between evaluation items

	Comfort	Beauty	Affinity	Ease of walking
Comfort	1.00			
Beauty	0.50	1.00		
Affinity	0.40	0.38	1.00	
Ease of walking	0.40	0.36	0.17	1.00

The summary for the physical characteristic is listed in the figure 5.2. In the figure, the blue chart bar represents Tokyo and the red chart bar represents Chengdu. P-value is calculated by Mann-Whitney Wilcoxon test. The significant difference can be observed in items (Q6: sidewalk pavement), (Q9: isolated/ open), (Q10: architecture), (Q11: density), (Q13: congestion), (Q16: residential house) and (Q17: factory). Expect item in Q16 (residential house) and item in Q17 (factory), the value of items relating to the maintenance around streets, such as item 'sidewalk pavement (Q6)', 'architecture (Q10)' in Tokyo is superior to in Chengdu. Relating to items such as 'isolated/ open (Q9)', 'density (Q11)', 'congestion (Q13)', Chengdu is superior to Tokyo.

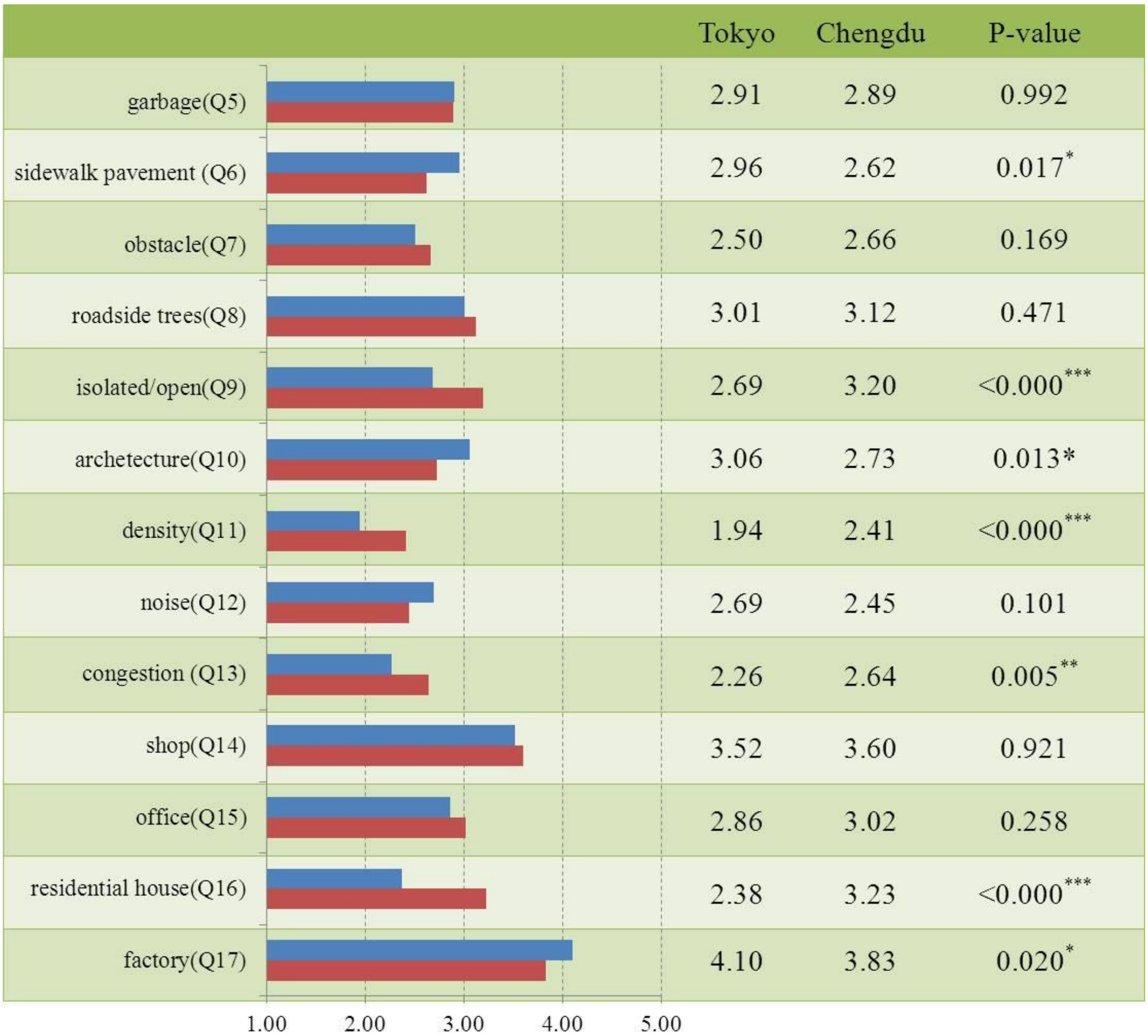


Figure 5. 2 Summary of physical characteristic in Tokyo and Chengdu
(blue chart bar : Tokyo ; red chart bar: Chengdu)

The spearman's rank correlation coefficient between physical characteristics and streetscape evaluation items is shown in table 5.2. The color pink in the cell of table pinpoints the value which is bigger than 0.30 and the color blue means that the value is larger than 0.40. As the factors involved in the street, item in Q5 (garbage), Q6 (sidewalk pavement), and Q7 (obstacle) obviously correlates with evaluation item in Q1 (comfort), as the correlation coefficients are all larger than 0.30. Factors involved in the surrounding environment such as 'architecture' and 'noise' also have higher positive correlation with 'comfort' with the larger than 0.30 correlation coefficient. Regarding to the streetscape evaluation item in Q2 (beauty), the physical characteristics that the correlation coefficient is larger than 0.30 with 'beauty' are items in Q5 (garbage), Q10 (architecture) and Q12 (noise). The correlation coefficient between these three physical characteristics and ‘comfort’ is also larger than 0.30 as we have explained above. Relating to the evaluation item in Q3 (affinity), there is nothing worthy of remark because of the less than 0.30 correlation coefficient overall. It is worthy of note that the spearman’s rank correlation coefficient between streetscape evaluation item in Q4 (ease of walking) and physical characteristic in Q7 (obstacles) reaches up to 0.427. In addition to that, the correlation coefficient between item in Q12 (noise), item in Q13 (congestion) and Q4 (ease of walking) is 0.323 and 0.347 respectively.

Table 5. 2 Spearman’s rank correlation coefficient between evaluation items and physical characteristics

(In the cell of table, [pink] > 0.30, [blue] >0.40)

	Comfort (Q1)	Beauty (Q2)	Affinity (Q3)	Ease of walking (Q4)
Q5.garbage	0.308	0.313	0.118	0.213
Q6.sidewalk pavement	0.329	0.295	0.230	0.295
Q7.obstacles	0.335	0.191	-0.043	0.427
Q8.roadside trees	0.076	0.233	-0.080	0.177
Q9 isolated/open	0.114	0.170	0.095	0.255
Q.10 architecture	0.323	0.388	0.254	0.292
Q.11 density	0.101	0.093	-0.257	0.281
Q.12 noise	0.369	0.306	0.140	0.323
Q.13 congestion	0.215	0.076	-0.107	0.347
Q.14 shops	0.078	0.071	0.278	-0.102
Q.15 office	-0.211	-0.158	-0.092	-0.134
Q.16 residential houses	-0.061	0.032	-0.114	0.066
Q.17 factory	0.138	0.224	0.204	0.001

The spearman’s rank correlation coefficients between physical characteristics are displayed in the table 5.3 below. The color pink in the cell of table pinpoints the value which is bigger than 0.30, the color blue means that the value is larger than 0.40 and the color orange represents that the value is larger than 0.50. From the table, it is easy to understand the correlation between physical characteristics themselves. The absolute value of correlation coefficient of ‘garbage’ and ‘obstacles’, ‘sidewalk’ and ‘architecture’, ‘obstacle’ and ‘density’, ‘obstacle’ and ‘noise’, ‘obstacle’ and ‘congestion’ , ‘density’ and ‘shop’, ‘congestion’ and ‘shop’ is larger than 0.30. Among them, the correlation coefficient of ‘density’ and ‘shop’, ‘congestion’ and ‘shop’ is negative. The correlation coefficient of ‘noise’ and ‘garbage’, ‘density’ and ‘congestion’ is 0.41 and 0.45 respectively. The value of correlation coefficient between item in Q12 (noise) and item in Q13 (congestion) deserves special note. The value 0.51 refers strong correlation between noise and congestion.

Table 5. 3 Spearman's rank correlation coefficient between physical characteristics

(In the cell of table, > 0.30, >0.40, >0.50)

	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17
Garbage(Q5)	1.00												
Sidewalk pavement(Q6)	0.28	1.00											
Obstacle(Q7)	0.39	0.26	1.00										
Roadside trees(Q8)	0.12	0.01	0.18	1.00									
Isolated/Open(Q9)	0.04	0.12	0.16	0.14	1.00								
Architecture(Q10)	0.29	0.33	0.24	0.12	0.12	1.00							
Density(Q11)	0.15	0.00	0.39	0.19	0.00	-0.02	1.00						
Noise(Q12)	0.41	0.23	0.35	0.17	-0.02	0.18	0.24	1.00					
Congestion(Q13)	0.26	0.12	0.38	0.16	0.07	0.09	0.45	0.51	1.00				
Shop(Q14)	-0.17	0.01	-0.23	-0.22	0.04	-0.04	-0.36	-0.24	-0.31	1.00			
Office(Q15)	-0.01	-0.06	-0.02	0.01	0.00	-0.01	-0.01	-0.19	-0.08	0.01	1.00		
Residential house(Q16)	0.06	-0.01	0.06	-0.03	0.00	-0.04	0.10	0.04	0.18	-0.07	-0.04	1.00	
Factory(Q17)	0.17	0.05	-0.14	-0.07	0.09	0.13	-0.25	0.04	-0.08	0.19	-0.12	-0.14	1.00

5.4 Exploration of factors affecting evaluation streetscape

In the previous section, the difference of streetscape evaluation and physical characteristic between Tokyo and Chengdu has been discussed. As a result, the sensitivity characteristics receive high commendation from respondents in Tokyo than in Chengdu. On the contrary, the functional characteristics are rated highly in Chengdu than in Tokyo. In this section, whether the physical characteristic from Q5 to Q17 influents the evaluation item from Q1 to Q4 and how the physical characteristic from Q5 to Q17 influents the evaluation item from Q1 to Q4 will be discussed by the conditional inference trees method. At the same time, region will be considered as an explanatory variable. Therefore, it is possible to explore the interaction from region×physical characteristic. To put it in another way, the regional physical influential factors can be explored.

In the method of conditional inference trees, streetscape satisfaction cluster is decided by the production rules on the basis of street physical characteristic and regions (Tokyo /Chengdu).

In this analysis, physical requirement in the streetscape development and maintenance which pays attention to landscape will be considered from the production rules of most satisfactory cluster and most unsatisfactory cluster.

Additionally, in order to verify the regional difference (Tokyo /Chengdu), the categorical variables to the region can be added to explanatory variable. Because the tree structure approach method is not dependent on the type of explanatory variables. If the regional difference is selected as a branch point, the physical factor in connection with subsequent branches becomes the characteristic (difference of influential factor) of that region.

5.4.1 Exploration of the factors affecting comfort

Table 5.4 is a result of the conditional inference trees to comfort.

Table 5. 4 Results of conditional inference trees to comfort evaluation

	Noise		Garbage		Architecture		Pavement		Region		Result
	≦2	＞2	＝1	＞1	≦4	＝5	＝1	＞1	Tokyo	Chengdu	
TN.1	○		○								1.86 (T:14, C:7)
TN.2	○			○			○				1.89 (T:4, C:5)
TN.3	○			○				○			2.82 (T:58,C:51)
TN.4		○			○				○		3.42 (T: 73, C: 0)
TN.5		○			○					○	2.86 (T:0, C:35)
TN.6		○				○					4.50 (T:10, C:2)

When noise is annoying (with a mark less than 2) and with a great deal of garbage (mark=1), comfort is the lowest with the mark 1.86. In this cluster, there is no significant difference in the proportion of the responded subjects to the whole between Tokyo and Chengdu. When noise is annoying (with a mark less than 2), the quantity of garbage is not extremely large (with a mark bigger than 1), and the quality of sidewalk pavement is not very bad (with a mark bigger 1), the mean value of the comfort is 2.82. The proportion of the respondents who did that response described above to the whole respondents is 51% in Chengdu city, accounts for more than half. The results in this cluster point to the conclusion that although garbage and sidewalk pavement are not negative replies to the comfort, there is dissatisfaction about noise. That is to say, compared with Tokyo, the dissatisfaction of Chengdu about noise is strong.

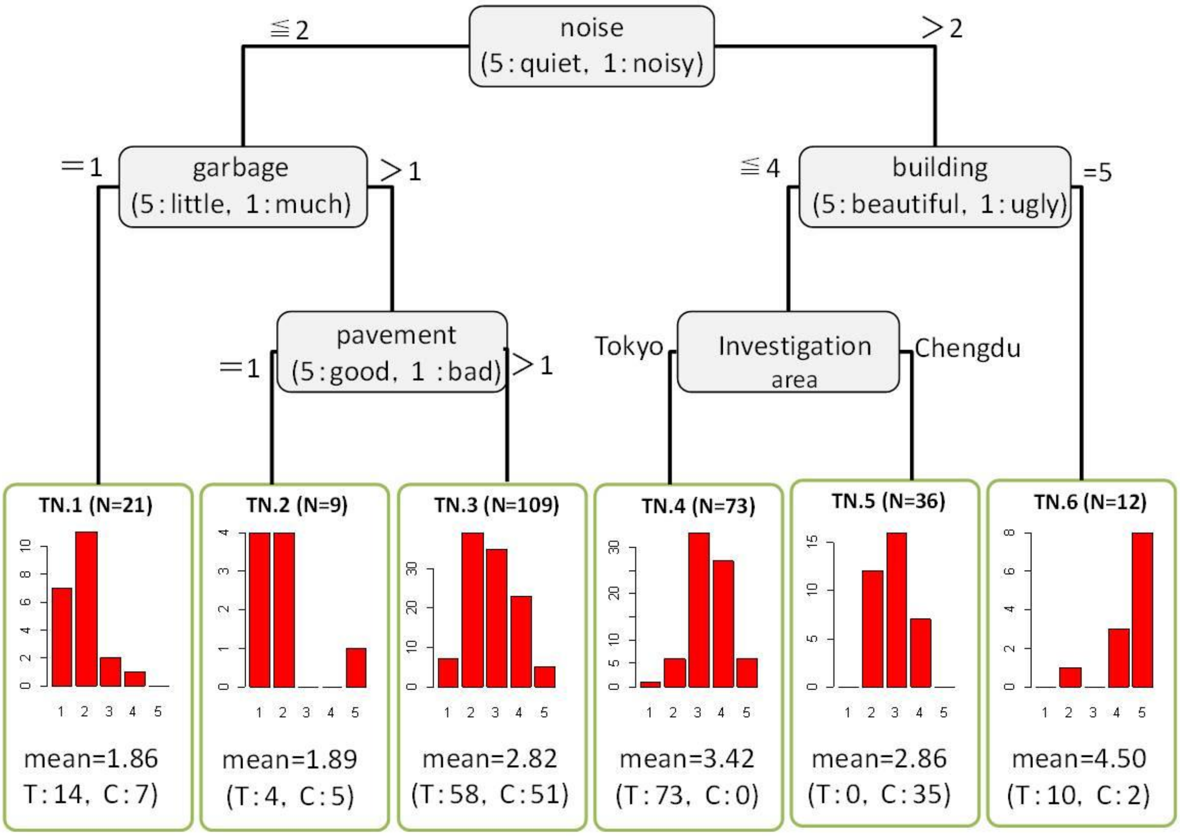


Figure 5. 3 Results of comfort evaluation by conditional inference trees

(In the node box, N means the size of sample. The numerical value at the bottom is the breakdown of Tokyo and Chengdu)

What is more, the evaluation result of the respondents who consider that the noise was not noisy (bigger than 2) and architecture cannot be said very beautiful (less than 5), is different in Tokyo and Chengdu, and the evaluation mark in Tokyo is higher than Chengdu (Tokyo: 3.42, Chengdu: 2.86). On the other hand, satisfaction for the comfort of the respondent who replied that the noise is not noisy (bigger than 2) and architecture is beautiful is the highest with the mark 4.50. Therefore, the surrounding environment is likely to contribute more strongly to satisfy the comfort of the streetscape than the street itself. On the other hand, that the garbage or sidewalk pavement affects comfort of streetscape negatively is suggested. To put it in another way, in street development and maintenance, as a controllable factor, such as garbage or sidewalk pavement, the importance is to avoid giving discomfort, rather than contributing to the comfortable streetscape. On this point, there is no difference between Tokyo and Chengdu.

Figure 5.3 is pictorial diagram of table 5.4. From the figure, we can get a clear understanding to the part discussed above. In the node box of the figure, N represents the size of sample. The numerical value at the bottom is the breakdown of Tokyo and Chengdu.

5.4.2 Exploration of the factors affecting beauty

Table 5.5 is a result of the conditional inference trees to beauty evaluation. Figure 5.4 is pictorial diagram of table 5.5. From the figure, we can get a clear understanding to the part discussed above. In the node box of the figure, N represents the size of sample. The numerical value at the bottom is the breakdown of Tokyo and Chengdu.

Table 5. 5 Results of conditional inference trees to beauty evaluation

	Architecture				Sidewalk pavement		office		Sidewalk tree		Result
	≦3	＞3	≦2	＞2	＝1	＞ 1	≦3	＞3	≦4	＝5	
TN.1	○				○						1.83 (T:10, C:8)
TN.2	○		○			○			○		2.56 (T:33, C:33)
TN.3	○			○		○			○		2.94 (T:53, C:41)
TN.4	○					○				○	3.72 (T:17, C:1)
TN.5		○					○				3.92 (T:38, C:11)
TN.6		○						○			2.50 (T:8), C:6)

The respondents' satisfaction of beauty gets to the highest (3.92) when they consider that the architecture is beautiful (bigger than 3) and with not many offices (less than 4). That is, the best beautiful area is to depend on the surrounding environment. On the other hand, the satisfaction of beauty extremely decreases to 2.5 when the quantity of office buildings is large (with a mark bigger than 3) despite the architecture is beautiful. In the central part of city, the office building is often new. As a result, the reason of significant reduction is considered to be that there is some possibility of stark landscape in such area.

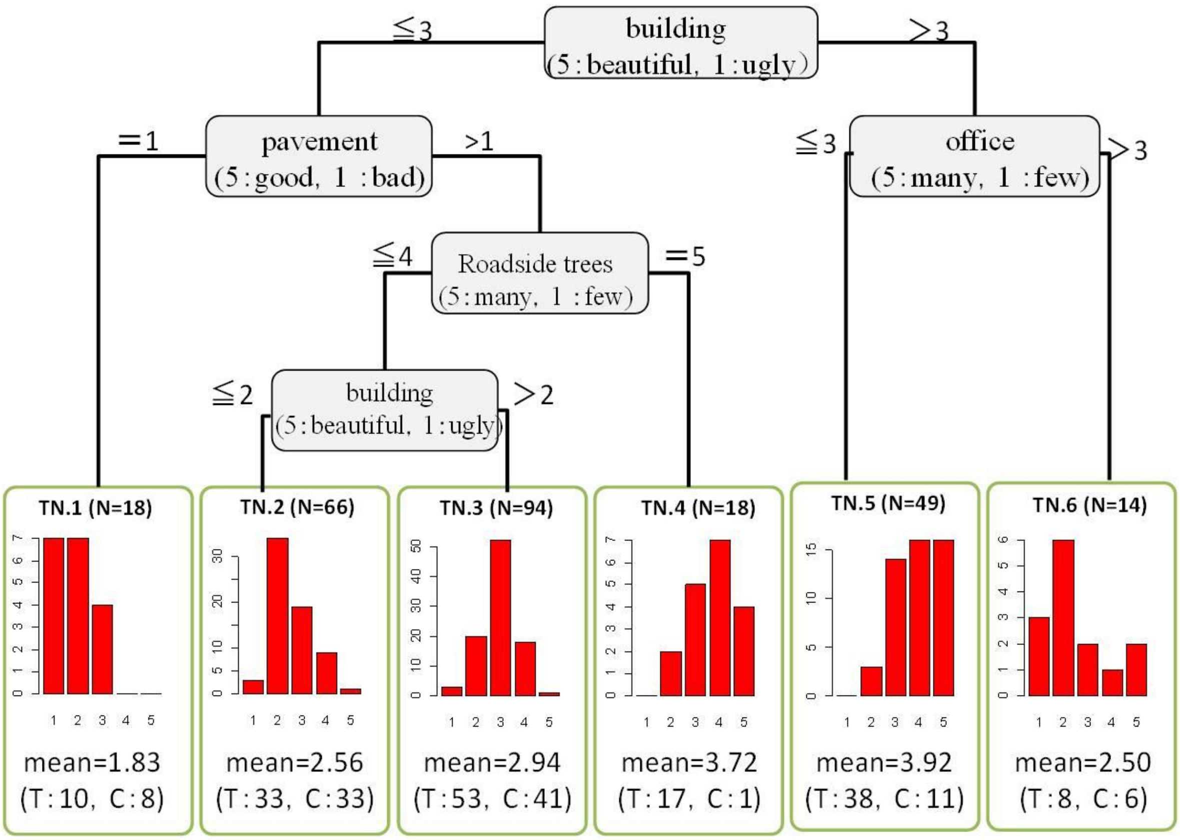


Figure 5. 4 Results of beauty evaluation by conditional inference trees

(In the node box, N means the size of sample. The numerical value at the bottom is the breakdown of Tokyo and Chengdu)

The lowest satisfaction to beauty is 1.83 when architecture is considered not beautiful (less than 3) and the quality of sidewalk pavement is considered poorest (=1). TN.2, TN.3, and TN.4 are clusters under the condition that the architecture is not very beautiful and the quality of sidewalk pavement is not very bad. The mean value of them is 2.56, 2.94, and 3.72 respectively. All of them exceed mean value of TN.1.We can infer that the poor pavement has a great bad influence on the beauty. The same with the result in comfort evaluation, sidewalk pavement is strongly associated with negative image in the beauty evaluation.

Comparing the TN.2, TN.3 with TN.4, we find that there is a great difference because of the quantity of the roadside trees. It hints that the big quantity of roadside trees has positive influence to evaluation on beauty. In the figure 5.2, we have noticed that, regarding to the image of sidewalk pavement and surrounding buildings, Chengdu is significant poor compared to Tokyo. That may be the reason to the evaluation difference of beauty between two cities.

5.4.3 Exploration of the factors affecting affinity

Table 5.6 is a result of the conditional inference trees to affinity evaluation.

Table 5. 6 Results of conditional inference trees to affinity evaluation

	Investigation area		Shop		Architecture		Result
	Tokyo	Chengdu	≦4	＝5	≦3	＞3	
TN.1	○		○				3.12 (T: 100), C: 0)
TN.2	○			○			4.19 (T: 59, C: 0)
TN.3		○			○		2.64 (T:0, C:83)
TN.4		○				○	3.53 (T:0, C:17)

All the data is classified into two groups by the factor investigation area at first. It shows that there is great difference in the affinity evaluation between Tokyo and Chengdu. As shown in figure 5.1, the mean value of affinity evaluation in Tokyo is 3.52 and the proportion of respondents who rated the affinity highly (larger than 4) is high. On the contrary, the mean value of affinity evaluation in Chengdu is 2.79 and many respondents gave mark 2 to the affinity evaluation.

Furthermore, different variables were selected at the second branch after being divided by the investigation region. It indicates that respondents in these two cities evaluated affinity from different viewpoint. In Tokyo, the affinity is high when there are many shops (with mark =5) along the street. In all likelihood, shopping district is regarded as a symbol of region ties in Japan. While in Chengdu, the evaluation on affinity is affected by the beauty of building. As shown in the figure, the affinity evaluation is not high under the condition that the surrounding building is not very beautiful (with the mark ≦3). Overall, the affinity evaluation in Chengdu depends on the surrounding maintenance such as the beauty of the buildings.

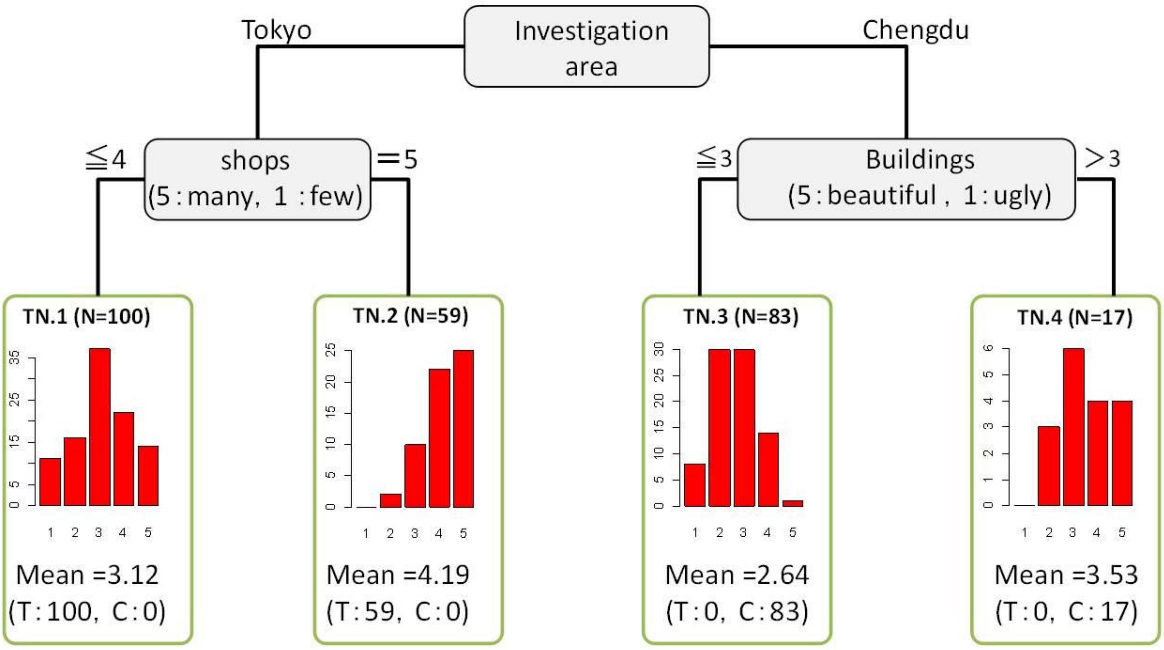


Figure 5. 5 Results of affinity evaluation by conditional inference trees

(In the node box, N means the size of sample. The numerical value at the bottom is the breakdown of Tokyo and Chengdu)

Figure 5.5 is pictorial diagram of table 5.6. From the figure, we can get a clear understanding to the part discussed above. In the node box of the figure, N represents the size of sample. The numerical value at the bottom is the breakdown of Tokyo and Chengdu.

5.4.4 Exploration of the factors affecting ease of walking

Table 5.7 is an evaluation result of walking ease by the conditional inference trees. Figure 5.6 is pictorial diagram of table 5.7. From the figure, we can get a clear understanding to the part discussed above. In the node box of the figure, N represents the size of sample. The numerical value at the bottom is the breakdown of Tokyo and Chengdu.

The results from the table5.7 and figure 5.6, we can observe that the factor obstacle has strong influence on the ease of walking, for the data is branched twice by the mark of factor obstacle.

Table 5. 7 Evaluation results of walking ease by conditional inference trees

	Obstacle				Noise		Pavement		Density		Result
	≦2	＞2	＝1	＝2	≦3	＞3	≦3	＞3	≦2	＞2	
TN.1	○		○								1.77 (T:30, C:15)
TN.2	○			○							2.37 (T:52, C:30)
TN.3		○			○		○				2.62 (T:34, C:31)
TN.4		○			○			○			3.93 (T:20, C:8)
TN.5		○				○			○		3.24 (T:13, C:4)
TN.6		○				○				○	4.00 (T:10, C:12)

The functionality (ease of walking) is extremely low if there are a very large number of obstacles (=1). It will be branched by the noise under the condition that there are few obstacles (>2). Noise, it feels like there is no direct relation to the ease of walking, but in figure 5.2, the spearman's rank correlation coefficient of the noise and congestion is 0.51, the respondents may get a bad image of walking ease because it is widely known that congestion leads to noisy surroundings.

In attrition to that, TN.3 and TN.4 is branched by the quality of the sidewalk pavement. The mean value is 2.62 and 3.93 respectively. The difference value between high quality pavement (bigger than 3) and low quality pavement (not bigger than 3) reaches up to 1.31. The quantity of obstacle strongly affects the ease of walking. The next is noise. In the research of Yang et al (2012b), the same conclusion has been investigated.

Although the quality of pavement affects the evaluation of walking ease, it is under the noisy environment. As there is no branch by the investigation area, it is considered that there is no difference in the tendency between two cites.

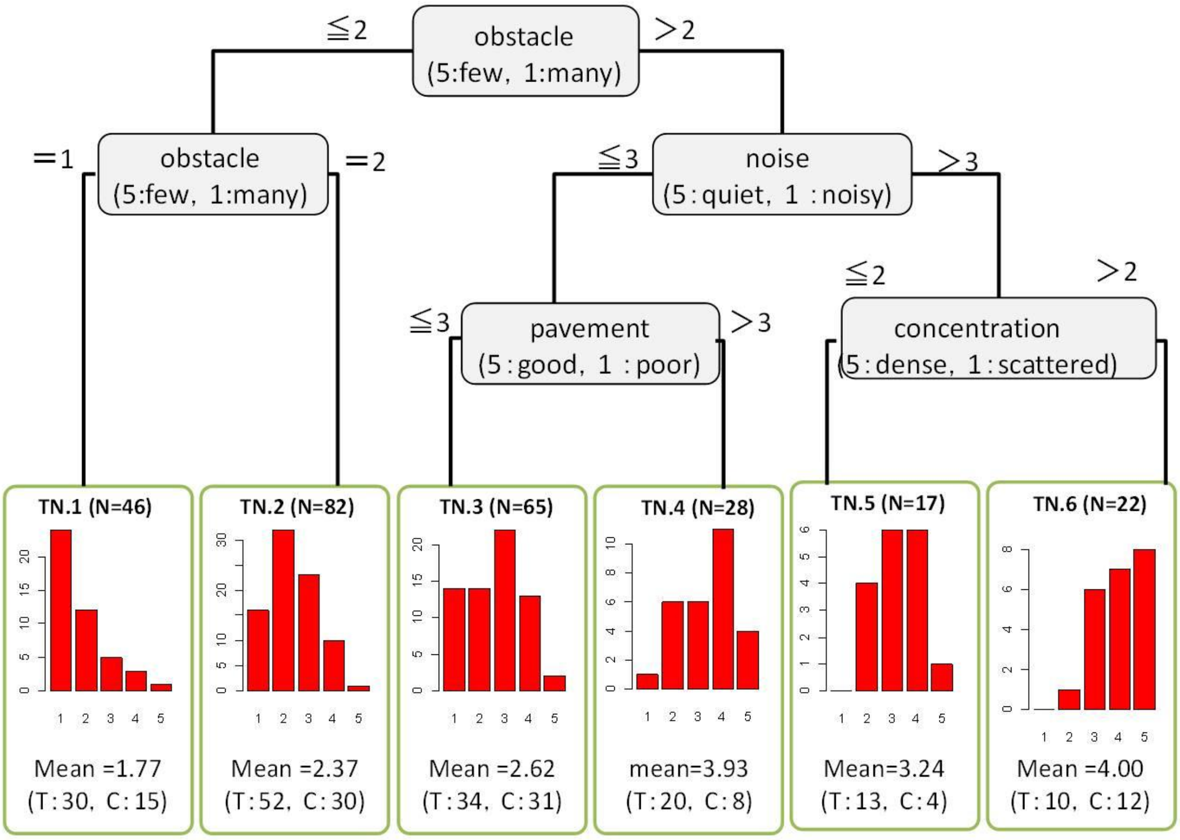


Figure 5. 6 Results of walking ease evaluation by conditional inference trees
(In the node box, N means the size of sample. The numerical value at the bottom is the breakdown of Tokyo and Chengdu)

5.5 Summary

Figure 5.7 shows the positive rule (the mean value in terminative node is larger than 4) and negative rule (the mean value in terminative node is less than 2) abstracted from figure 5.3 to figure 5.6. What is more, the difference between Tokyo and Chengdu is also abstracted.

Item in Q10 (architecture) is important to get high satisfaction of comfort and beauty. As shown in figure 5.2, the point of the item in Q10 (architecture) is significant higher in Tokyo than in Chengdu. It can be considered to lead to the superiority of comfort evaluation and beauty evaluation.

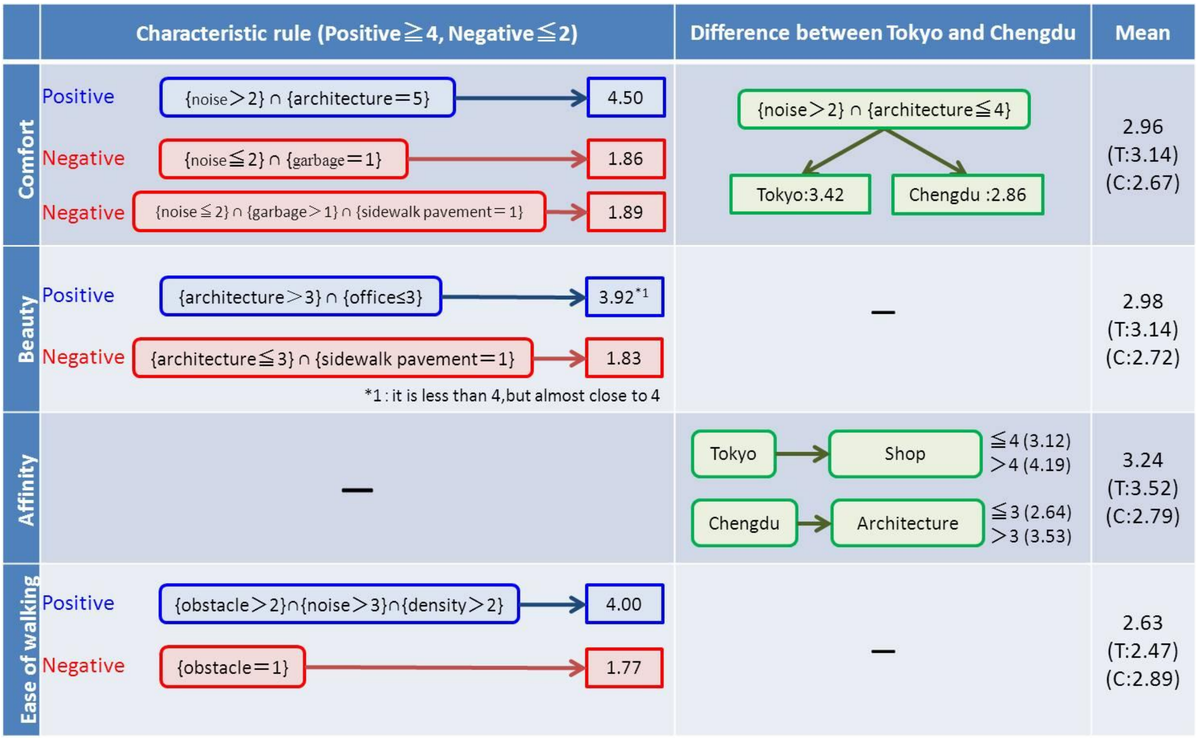


Figure 5. 7 the summary of conditional inference trees to four streetscape evaluation items

Item in Q6 (sidewalk pavement) has contributed to a negative image in both comfort evaluation and beauty evaluation. In either case, when the cut-off value of sidewalk pavement is 1, the evaluation on both comfort and beauty becomes worse. In fact, as shown in figure 5.2, the sidewalk pavement in Tokyo was significantly better than in Chengdu. It also may show the connection with the superiority in comfort and beauty in Tokyo. Furthermore, that the comfort was influenced by garbage was also suggested. Specially, street-cleaning is important in reducing the discomfort because the garbage is a negative factor of comfort, and it seems that there is no regional difference between Tokyo and Chengdu.

Regarding to the difference in comfort evaluation between Tokyo and Chengdu , there are 2 terminative nodes branched by the rule {noise＞2}∩{building≦4}. From the bar graph in the terminative node TN.4 and TN.5 of Figure 5.3, it indicates that more respondents in Tokyo feel slightly comfortable under the streetscape like that, while in Chengdu, respondents feel slightly uncomfortable.

In the beauty evaluation, there is no branch by investigation region, but we can see that there is a bias in the sample size of Tokyo and Chengdu in the TN.4 (Figure 5.4). However, rather than the difference of the beauty between two cities, it is should be considered that the number of respondents corresponding to TN.4 in Chengdu is few.

Regarding to the affinity evaluation shown in figure 5.5, because all the data were branched by Tokyo and Chengdu at first, the answers from respondents were very different by the region. In the subsequent branch of Tokyo, the data was further branched by the quantity of shop, more shops(≧4) made the affinity increasing with the mean value up to 4.19. On the other hand, the data was further branched by the architecture in Chengdu, the mean value of affinity decreased to 2.64, less than 3 when the building was not very beautiful (with a mark less than 3).

Regarding to the ease of walking, the effect of the obstacle was remarkable in both positive and negative image. Additionally, as the positive image, not only the obstacle but also the factors associated with bustling image such as noise and density affected the evaluation of walking ease. At this time, regional differences between Chengdu and Tokyo were not observed.

Chapter 6 Conclusions and recommendations

6.1 Conclusions

In this research, the new methodology was introduced to clarify the physical factors affecting the streetscape evaluation and reveal the distinction of influential physical factors between Japan and China. The study areas were chosen to be Tokyo 23 wards in Japan and Chengdu 5 central districts in China. The survey was conducted from wide roads (primary and district distributor roads) and narrow roads (local distributor roads) respectively. The following conclusions can be drawn.

1. Regarding to the wide roads (primary and district distributor roads), there was no significant difference in comfort evaluation and beauty evaluation, but the activity score of Tokyo was significantly higher than Chengdu.

2. For comfort evaluation of wide roads, the quantity of shops played an important role in both Tokyo and Chengdu. With the increasing of shops' quantity, the comfort evaluation decreased. Besides that, density had a strong effect on comfort in Chengdu's wide roads, and they were in inverse relation. It was suggested that for Chengdu, comfort of wide road's streetscapes is strongly influenced by landscape and spatial situation.

3. With respect to the beauty evaluation of wide roads, the density had the strongest influence in both Tokyo and Chengdu, beauty reduced heavily at greater scattering. An increase in the quantity of houses decreased the level of beauty in Tokyo but increased that in Chengdu. The impact of buildings on beauty was stronger in Tokyo than in Chengdu.

4. In relation to the activity evaluation of wide roads, the congestion of streets had the strongest influence for both Tokyo and Chengdu. When streets become vacant, the activity decrease.

5. For the perceptual item (comfort, beauty, affinity), much more have been satisfied in Tokyo's local distributor roads and for the functional item (ease of walking), more have been satisfied in Chengdu's local distributor roads

6. The beauty of the architecture affects comfort and beauty evaluation of local distributor roads. Especially, to the positive impression, impact of the beautiful surrounding buildings is very important. At the same time, the impact of the beauty of the architecture is much more remarkable to the comfort evaluation in Chengdu’s local distributor roads than that of Tokyo.

7. Maintenance of sidewalk pavement was a very important way to eliminate the negative impression of comfort and beauty in local distributor roads. That is, the high quality sidewalk pavement did not have much impact to the comfortable or beautiful streetscape, but the poor sidewalk pavement certainly led to an uncomfortable or ugly streetscape.

8. Maintenance of roadside trees was important to comfort evaluation of local distributor roads as a positive factor.

9. Tokyo had a stronger affinity of the local distributor road than Chengdu. And in Tokyo, the quantity of shops (Functional aspects of the streets) contributed to the affinity, while in Chengdu, the beauty of buildings (Scene aspects of the streets) contributed to the affinity.

10. The ease of walking was strongly impacted by the obstacles of local distributor roads. In addition to that, by strengthening the quality of sidewalk pavement, the walking ease could be improved dramatically.

6.2 Recommendations

In addition to the aforementioned achievements and contributions, we think that the following research prospects related to this study are worth further investigation:

1. From the statistical analysis results, a deficiency of sample size can be seen. Although comparing to the existed research, the sample size is not small, we also need to enlarge the sample size to obtain a complete tendency. As a result, the minute description of the data can be given.

2. The survey was only conducted in Tokyo and Chengdu. Although, they are the typical cities in their own countries, it is necessary to investigate more cities to enrich the samples.

Additionally, the investigation regions in this research were both Asian cities, more research should be done in European cities where the streetscape develops well. What is more, the respondents in the survey were all university students, and the age was mainly concentrated in the age group twenties. The future study was supposed to cover different group ages. In that case, the common influential factors from various factors that affect the streetscape evaluation in different cultures, different regions and by different people can be extracted. At the same time, the international model for streetscape evaluation may be constructed.

3. Similar to this study, a vast amount of research with subjective data has been performed to evaluate streetscape. Few attempts have been made pertaining to the stress relaxing effect of streetscape by physiological-psychological analyses based on objective data. Muto et al. (2010, 2011) of our research group compared psychological and behavioural indicators for the evaluation of river landscape. And Li et al. (2013) also conducted some tentative relative studies. It is supposed to conduct physiological-psychological analyses based on objective data of this research.

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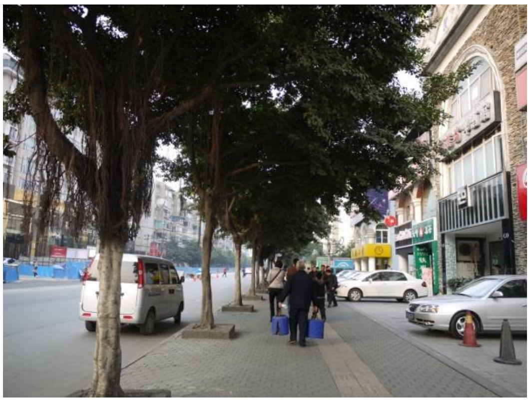
Appendix A

The typical streetscape images in Japan and China

Tokyo, Japan

Chengdu, China



Appendix B

The questionnaires in Japan and China

東京都山の手線内及び周辺部街路景観の評価に関する調査のお願い

このアンケート調査は、東京都山の手線内及び周辺の街路景観の現状や今後の街路景観施策の方向性を研究しており、皆さんの景観意識について伺いたく実施するものです。現在の東京都山の手線内及び周辺の街路景観などについて、市民の皆さんの率直なお考えをおうかがいします。

ご多忙のところ誠に恐れ入りますが、調査の趣旨をご理解いただき、ご協力くださいますようお願い申し上げます。

山梨大学大学院医学工学綜合研究部・教育部
環境社会創生工学専攻
教授　北村眞一
博士課程　李力

あなた自身のことについておたずねします

1 あなたの年齢は？

1．20 歳未満	2．20 歳代	3．30 歳代

2 あなたの所属は？

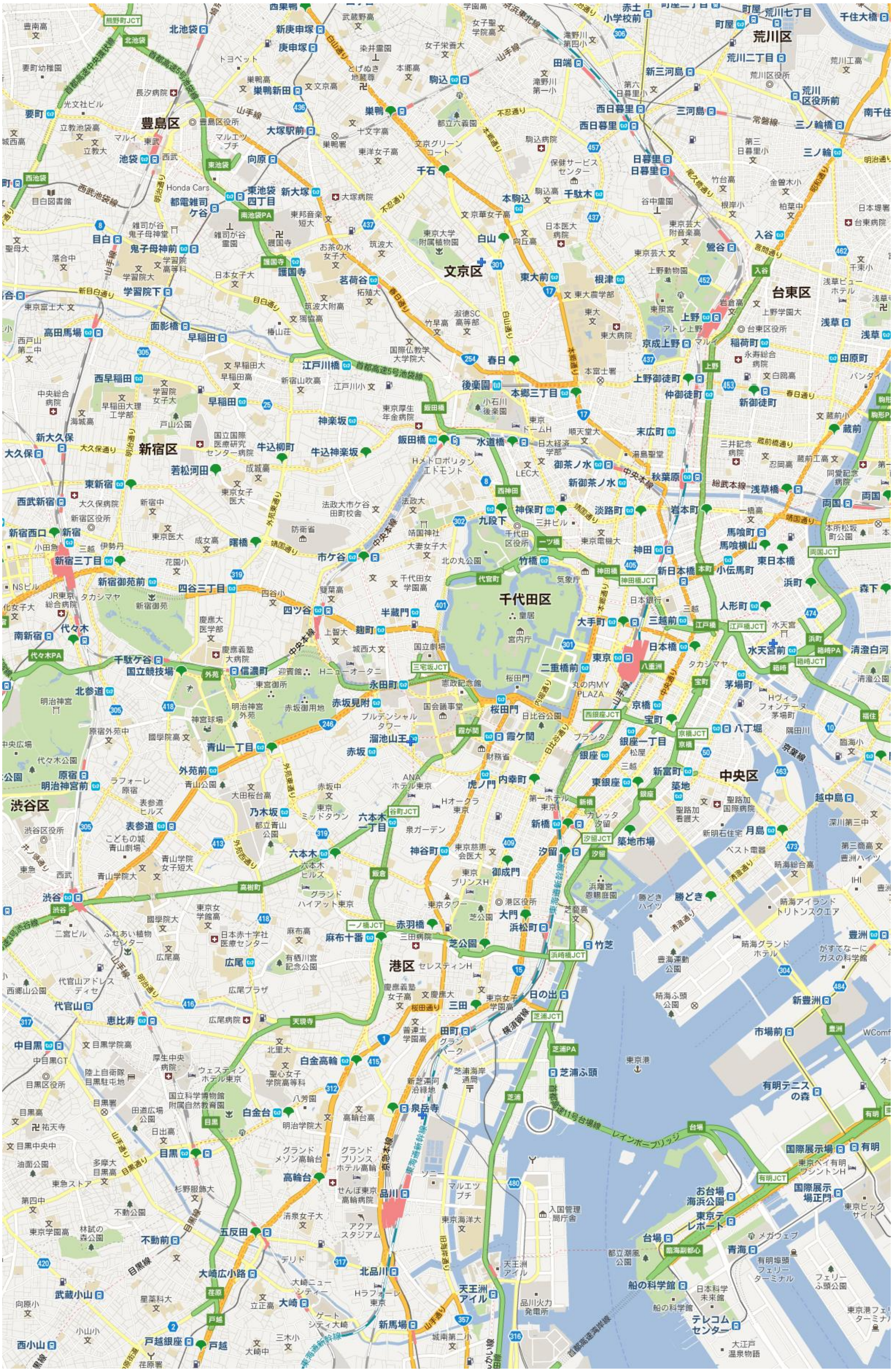
1．大学生	2．修士	3．博士

3 あなたの性別は？

1．男性	2．女性

4 あなたは東京都に住んでどれぐらいになりますか。

1．2 年未満	2．2 年以上 5 年未満	3．5 年以上


豊島区
文京区
荒川区
台東区
新宿区
千代田区
中央区
渋谷区
港区
池袋
目白
高田馬場
早稲田
新大久保
新宿
新宿三丁目
代々木
原宿
渋谷
恵比寿
目黒
五反田
大崎
品川
田町
浜松町
新橋
有楽町
東京
神田
秋葉原
御茶ノ水
上野
日暮里
西日暮里
田端
駒込
巣鴨
大塚
飯田橋
市ケ谷
四ツ谷
信濃町
千駄ケ谷
青山一丁目
赤坂
六本木
麻布十番
広尾
白金高輪
泉岳寺
高輪台
北品川
新馬場
天王洲アイル
お台場海浜公園
台場
船の科学館
テレコムセンター
国際展示場
有明
新豊洲
豊洲
月島
築地
銀座
日本橋
人形町
浅草橋
両国
蔵前
水天宮前
茅場町
八丁堀
霞ケ関
虎ノ門
神谷町
御成門
大門
芝公園
三田
竹芝
芝浦ふ頭
日の出
皇居
東京ドーム
後楽園
春日
本郷三丁目
東大前
白山
千石
茗荷谷
護国寺
江戸川橋
神楽坂
牛込神楽坂
牛込柳町
若松河田
曙橋
四谷三丁目
新宿御苑前
国立競技場
北参道
明治神宮前
表参道
外苑前
乃木坂
代官山
中目黒
不動前
武蔵小山
西小山
戸越銀座
戸越
大崎広小路
白金台
レインボーブリッジ
首都高速11号台場線
首都高速5号池袋線

東京都山の手線内及び周辺の街路景観の現状についておたずねします

印象に残っている広い道は ________________（３車線以上車道と歩道両方がある道）
（地名、街路名を記入して下さい。
２ページ地図上にだいたいの位置を記入して下さい）

例：Q1　良い　5 － 4✓ － 3 － 2 － 1　悪い

その街路の現状は

Q1	良い	5 － 4 － 3 － 2 － 1	悪い
Q2	不快な	5 － 4 － 3 － 2 － 1	快適な
Q3	美しい	5 － 4 － 3 － 2 － 1	醜い
Q4	不統一感である	5 － 4 － 3 － 2 － 1	統一感がある
Q5	面白い	5 － 4 － 3 － 2 － 1	面白くない
Q6	親しみにくい	5 － 4 － 3 － 2 － 1	親しみやすい
Q7	賑わいがある	5 － 4 － 3 － 2 － 1	寂れている
Q8	歩きにくい	5 － 4 － 3 － 2 － 1	歩きやすい
Q9	ゴミがない	5 － 4 － 3 － 2 － 1	ゴミが多い
Q10	障害物が多い	5 － 4 － 3 － 2 － 1	障害物がない
Q11	歩道舗装がよい	5 － 4 － 3 － 2 － 1	歩道舗装が悪い
Q12	街路樹が少ない	5 － 4 － 3 － 2 － 1	街路樹が多い
Q13	開放的	5 － 4 － 3 － 2 － 1	閉鎖的
Q14	建物が醜い	5 － 4 － 3 － 2 － 1	建物がきれい
Q15	散在した	5 － 4 － 3 － 2 － 1	密集した
Q16	音がうるさい	5 － 4 － 3 － 2 － 1	音が静か的
Q17	空いている	5 － 4 － 3 － 2 － 1	混雑している
Q18	商店が少ない	5 － 4 － 3 － 2 － 1	商店が多い
Q19	住宅が多い	5 － 4 － 3 － 2 － 1	住宅が少ない
Q20	事務所が少ない	5 － 4 － 3 － 2 － 1	事務所が多い
Q21	工場が少ない	5 － 4 － 3 － 2 － 1	工場が多い

東京都山の手線内及び周辺の街路景観の現状についておたずねします

印象に残っている狭い道は ＿＿＿＿＿＿＿＿ （２車線以下車道と歩道両方がある道）

（地名、街路名を記入して下さい。

２ページ地図上にだいたいの位置を記入して下さい）

例：Q1　　良い　5 － 4✓ － 3 － 2 － 1　悪い

その街路の現状は

Q1	快適な	5 － 4 － 3 － 2 － 1	不快な
Q2	醜い	5 － 4 － 3 － 2 － 1	美しい
Q3	面白い	5 － 4 － 3 － 2 － 1	面白くない
Q4	歩きにくい	5 － 4 － 3 － 2 － 1	歩きやすい
Q5	ゴミがない	5 － 4 － 3 － 2 － 1	ゴミが多い
Q6	歩道舗装が悪い	5 － 4 － 3 － 2 － 1	歩道舗装がよい
Q7	障害物がない	5 － 4 － 3 － 2 － 1	障害物が多い
Q8	街路樹が少ない	5 － 4 － 3 － 2 － 1	街路樹が多い
Q9	開放的	5 － 4 － 3 － 2 － 1	閉鎖的
Q10	建物が醜い	5 － 4 － 3 － 2 － 1	建物がきれい
Q11	散在した	5 － 4 － 3 － 2 － 1	密集した
Q12	音がうるさい	5 － 4 － 3 － 2 － 1	音が静か的
Q13	空いている	5 － 4 － 3 － 2 － 1	混雑している
Q14	商店が少ない	5 － 4 － 3 － 2 － 1	商店が多い
Q15	事務所が多い	5 － 4 － 3 － 2 － 1	事務所が少ない
Q16	住宅が少ない	5 － 4 － 3 － 2 － 1	住宅が多い
Q17	工場が少ない	5 － 4 － 3 － 2 － 1	工場が多い

成都市街道景观评价调查

本调查的目的是为了研究成都市街道景观的现状、了解市民的景观意识，把握今后对街道景观的施策方向。我们希望得到您对现阶段成都市街道景观情况的率直的看法。

感谢您在百忙之中完成本份问卷，您对此次调查目的的理解，我们表示由衷的谢意，同时非常感谢您的合作！

西南交通大学交通运输学院

山梨大学大学院医学工学総合研究部

请填写以下关于您个人的信息

1、您的姓名是：

2、您的年龄是：

① 未满 20 周岁	② 20 来岁	③ 30 来岁

3、您的学历是：

① 本科在读	② 硕士在读	③ 博士在读

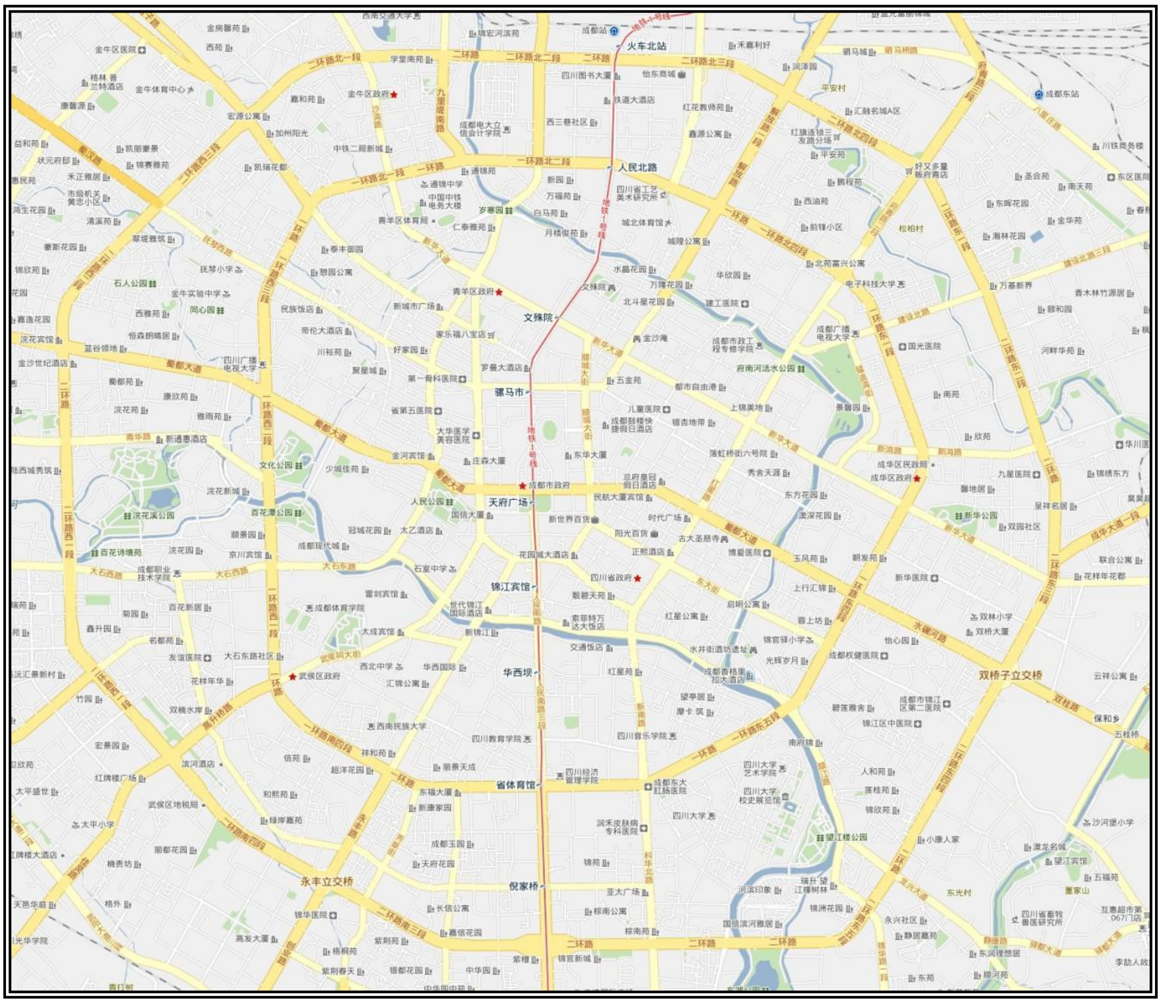
4、您的性别是：

① 男	② 女

5、您在成都的居住时间：

① 不到 2 年	② 2 至 5 年	③ 5 年以上

请在如下地图中标示出您印象中觉得宽阔的和狭窄的道路。（与后面的调查内容对应）



成 都 市 街 道 景 观 现 状 问 卷 调 查

有印象的宽阔街道的名称是 ____________________（含有 3 条以上机动车道和步行道的街道）

（请在上方横线处填入地名或街道名。

并在第二页的地图中标记上街道所处的大致位置）

例：Q1	好	5 – 4✓ – 3 – 2 – 1	差

这条街道现状是

Q1	好	5 – 4 – 3 – 2 – 1	差
Q2	不舒适	5 – 4 – 3 – 2 – 1	舒适
Q3	美	5 – 4 – 3 – 2 – 1	丑
Q4	无统一感	5 – 4 – 3 – 2 – 1	有统一感
Q5	有趣的	5 – 4 – 3 – 2 – 1	无趣的
Q6	无亲近感的	5 – 4 – 3 – 2 – 1	有亲切感的
Q7	热闹的	5 – 4 – 3 – 2 – 1	静寂的
Q8	不便于行走	5 – 4 – 3 – 2 – 1	便于行走
Q9	垃圾少	5 – 4 – 3 – 2 – 1	垃圾多
Q10	障碍物多	5 – 4 – 3 – 2 – 1	无障碍物
Q11	步行道铺装好	5 – 4 – 3 – 2 – 1	步行道铺装差
Q12	行道树少	5 – 4 – 3 – 2 – 1	行道树多
Q13	开放	5 – 4 – 3 – 2 – 1	封闭
Q14	建筑物丑	5 – 4 – 3 – 2 – 1	建筑物美
Q15	散松	5 – 4 – 3 – 2 – 1	密集
Q16	喧闹的	5 – 4 – 3 – 2 – 1	安静的
Q17	道路空荡	5 – 4 – 3 – 2 – 1	道路拥挤
Q18	商店少	5 – 4 – 3 – 2 – 1	商店多
Q19	住宅多	5 – 4 – 3 – 2 – 1	住宅少
Q20	办公楼少	5 – 4 – 3 – 2 – 1	办公楼多
Q21	工厂少	5 – 4 – 3 – 2 – 1	工厂多

成 都 市 街 道 景 观 现 状 问 卷 调 查

有印象的狭窄街道的名称是 ____________________（含有 2 条以下机动车道和步行道的街道）

（请在上方横线处填入地名或街道名。

并在第二页的地图中标记上街道所处的大致位置）

例：Q1　　舒适　5 – 4✓ – 3 – 2 – 1　不舒适

这条街道现状是

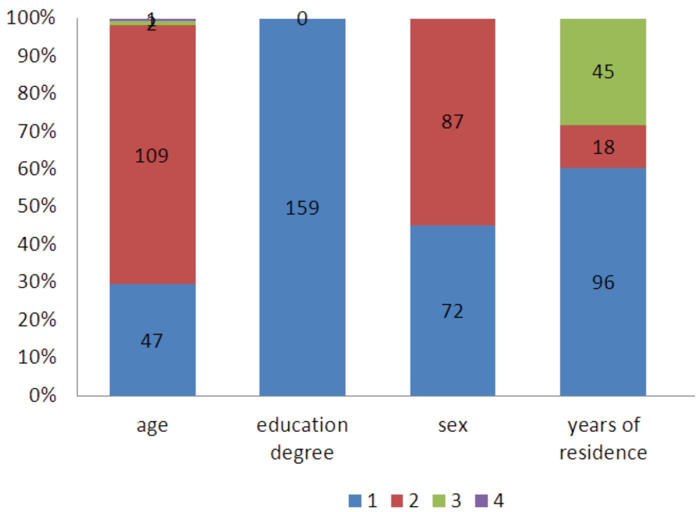
Q1	舒适	5 – 4 – 3 – 2 – 1	不舒适
Q2	丑	5 – 4 – 3 – 2 – 1	美
Q3	有趣的	5 – 4 – 3 – 2 – 1	无趣的
Q4	不便于行走	5 – 4 – 3 – 2 – 1	便于行走
Q5	垃圾少	5 – 4 – 3 – 2 – 1	垃圾多
Q6	步行道铺装差	5 – 4 – 3 – 2 – 1	步行道铺装好
Q7	无障碍物	5 – 4 – 3 – 2 – 1	障碍物多
Q8	行道树少	5 – 4 – 3 – 2 – 1	行道树多
Q9	开放	5 – 4 – 3 – 2 – 1	封闭
Q10	建筑物丑	5 – 4 – 3 – 2 – 1	建筑物美
Q11	散松	5 – 4 – 3 – 2 – 1	密集
Q12	喧闹的	5 – 4 – 3 – 2 – 1	安静的
Q13	道路空荡	5 – 4 – 3 – 2 – 1	道路拥挤
Q14	商店少	5 – 4 – 3 – 2 – 1	商店多
Q15	住宅多	5 – 4 – 3 – 2 – 1	住宅少
Q16	办公楼少	5 – 4 – 3 – 2 – 1	办公楼多
Q17	工厂少	5 – 4 – 3 – 2 – 1	工厂多

Appendix C

Raw data for analysis

Raw data of wide streetscape survey

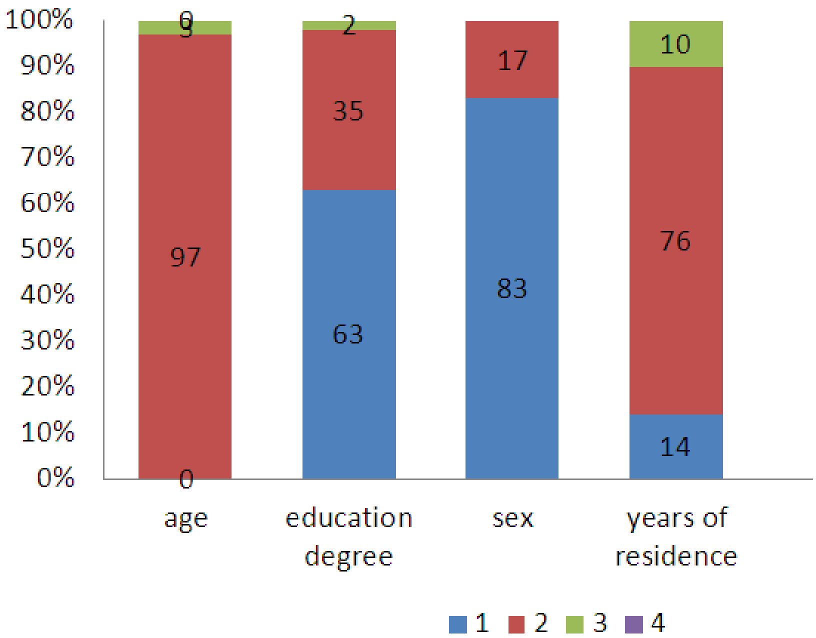
Evaluation point / Items	Tokyo					Chengdu				
	1	2	3	4	5	1	2	3	4	5
Q1	3	13	39	64	40	2	5	31	41	21
Q2	5	20	60	52	22	3	16	33	42	6
Q3	2	35	51	43	28	2	10	37	38	13
Q4	11	24	50	47	27	6	24	22	33	15
Q5	7	23	58	50	21	5	19	51	22	3
Q6	9	38	50	39	23	5	20	34	35	6
Q7	0	11	30	41	77	2	9	25	44	20
Q8	13	35	38	49	24	5	17	40	28	10
Q9	21	32	51	36	19	2	9	32	41	16
Q10	16	29	59	42	13	7	14	46	28	5
Q11	2	8	42	52	55	3	16	32	40	9
Q12	16	29	60	32	22	8	18	35	33	6
Q13	1	22	45	49	42	3	14	26	40	17
Q14	4	18	50	39	48	4	13	39	34	10
Q15	51	37	52	17	2	16	39	26	17	2
Q16	50	63	37	5	4	15	38	32	12	3
Q17	56	46	39	14	4	10	32	36	18	4
Q18	17	22	37	32	51	4	18	29	28	21
Q19	83	39	20	13	4	9	28	33	24	6
Q20	9	14	81	35	20	8	25	30	32	5
Q21	5	13	28	35	78	1	11	16	24	48



Information of survey subjects in Tokyo

Raw data of narrow streetscape survey

Evaluation point / Items	Tokyo					Chengdu				
	1	2	3	4	5	1	2	3	4	5
Q1	11	30	59	43	16	8	43	27	18	4
Q2	8	37	58	36	20	8	35	38	15	4
Q3	11	18	47	44	39	8	33	36	18	5
Q4	44	43	38	21	13	11	26	30	29	4
Q5	15	37	65	32	10	8	31	27	32	2
Q6	14	42	55	33	15	10	37	35	17	1
Q7	30	52	51	19	7	15	30	29	26	0
Q8	24	30	49	32	24	6	26	25	36	7
Q9	21	55	45	29	9	3	30	23	32	12
Q10	6	41	66	29	17	8	32	43	13	4
Q11	74	40	31	8	6	18	42	25	11	4
Q12	29	47	40	30	13	17	46	17	15	5
Q13	56	41	38	12	12	15	35	26	19	5
Q14	24	18	28	30	59	3	18	21	32	26
Q15	16	29	82	25	7	10	22	34	24	10
Q16	42	54	37	13	13	8	29	15	28	20
Q17	4	12	29	33	81	3	10	20	35	32



Information of survey subjects in Chengdu