CHAPTER 2 LITERATURE REVIEW

2.1 Discipline History

Given its long history, cycling has brought personal spatial freedom since the 1890s (Ryan, 2003). Researchers from New Zealand and the U.K. have approached cycling in modern societies from the perspective of bicycle tourism (Cope, Doxford, & Hill, 1998; Lumsdon, 2000; Mason & Leberman, 2000; Page, 1999; Ritchie, 1998). They have examined the impact of bicycle tourism development on the environment and the economy from an overall supply perspective, and also discussed cycling features such as long-distance and overnight trips, as well as mountain biking. Prideaux (2000) also recognized that availability of cycling as a mode of transportation is related to choice of tourism destination.

Cope et al. (1998) described a research program carried out on a long distance cycle route in northern England during 1996-1997. Cope sought to profile users, monitor the overall number of users, describe their spatial and temporal distribution, and quantify their economic impact. Cope also was also concerned about the performance of the route in terms of the cycle tourism niche.

Lumsdon (2000) discussed the relationship between transportation and tourism; the former is not only a means but also a component of the tourism offering, especially at the destination. Lumsdon evaluated the concept of a planned sustainable transport network, the National Cycle Network in the UK, as a potential model for the integration of transportation, tourism and recreation. He also defined cycle tourism as recreational cycling activities ranging from a day or part-day casual outing to a long distance touring holiday.

Mason & Leberman (2000) suggested that planning for recreation and tourism is not necessarily a straightforward process at the local level. Local policy makers may be unable to reflect the complexity of the planning process, particularly when they should consider a variety of views from different stakeholder.

Ritchie (1998) indicted the emerging trends of the bicycle as an important leisure and recreational transportation mode. Little research has been conducted into cycling within a tourism context. Ritchie examined the increasing phenomenon of bicycle tourism, and recommends for future planning and management of bicycle tourism in New Zealand.

Previous studies on cycling in modern American societies have focused on the bicycle-as-transportation perspective. Some works have examined cycling in terms of route choice, bicycle use and attitudes, travel behavior and accidents, demand forecasting, and the relationship between facility supply and usage (Aultman-Hall & Hall, 1998; Moritz, 1998; Porter, Suhrbier, & Schwartz, 1999; Taylor & Davis, 1999).

Allen, Rouphail, Hummer, et al. (1998) categorized cyclists as advanced, basic, or child. Advanced cyclists, including experienced, knowledgeable, and skilled cyclists, constitute 10% of the cyclist population in the United States. Basic cyclists are occasional or inexperienced riders who consider cycling to be a recreational activity and prefer to use dedicated bicycle routes. Basic cyclists constitute 40% of the cyclist population in the United States. The remaining cyclists are children.

Antonakos (1996) indicted that the current recommendations for designing bicycle facilities are most often based on experience rather than on findings from scientific inquiry. Antonakos examined the influence of personal characteristic, travel resources, and travel constraints on cyclists' environmental preferences, evaluations of cycling conditions, and decisions to bicycle for transportation.

Jackson and Ruehr (1998) investigated the San Diego Association of Governments which allocates 2 million dollars annually on bicycling projects throughout San Diego County. Both the County and the City employ full-time bicycle coordinators. The County Public Works Department commissioned the County Bicycle Use and Attitude Survey. Overall, survey respondents expressed support for government efforts to promote bicycle transportation.

Nelson and Allen (1997) argued that conventional wisdom suggests that if bicycle pathways are provided, people will use them. Nelson and Allen used cross-sectional studies of the association between supply and commuting. Schuett and Holmes (1996) undertook a collaborative approach to develop the Bicycle Tourism Master Plan for the Northeast in the U.S.A.

Taylor and Davis (1999) reviewed basic research on bicycles in 1999 in 67 publications. They organized their studies into 7 categories: bicycle/rider characteristics, traffic flow, intersection control, capacity and level of service, networks, computer models, and geometric designs.

The Transportation Research Board in the United States produces annual publications about the issues of bicycling. More than 40 documents were reviewed from the years 1996 to 2004, and the issues of the study were divided into 5 categories: simulation and evaluation of bicycle facility, traffic management and safety, bike lane and facility design, cyclist characteristics, and forecasting and review. The documents about the characteristics and the study of bicycle usage in recent years have mostly focused on the usage of bicycles as far as the bicycle commuting is concerned.

2.2 Bicycle Tourism Development

The documents giving the idea of combining bicycles with developing tourism at the present stage are mainly to meet the purpose of practicality and implementation. Those include the Institute of Transportation Engineers (1994), the city of Windsor in Canada (2001), the state of New York (2002), and the city of Copenhagen (2003).

The City of Windsor, Canada, has been developing a cycling and recreation network since 1991 with the adoption of the Bicycle Use Development Study (BUDS). The completion of a comprehensive cycling network is viewed as integral to Windsor's vision for a balanced transportation system. In year 2000, the city furthermore completed the Bicycle Use Master Plan (BUMP), the purpose of which is to guide the development of a comprehensive cycling network that will make it the preeminent city for cycling in North America.

In year 2002, Adirondack North County in America completed a Bicycle Master Plan. Its purpose is to develop a regional bicycle plan that clearly demonstrates the community benefits and economic value of local bicycle planning efforts, and outlines the next steps necessary for creating bicycle-friendly communities and for promoting the region's reputation as a bicycle tourism destination.

The Institute of Transportation Engineers in the U.S.A. took a leading role in the encouragement and enhancement of cycling as a transportation choice. They learned the rich cultural affinity for cycling from the Scandinavian countries where non-motorized transportation technology and management is emphasized. (ITE, 1994)

The City of Copenhagen implemented the Free-City Bike Program in 1995. Under that program, 1000 specially designed Free City-Bikes were stationed at 120 stands around the city at train and subway stations, parking lots, and large housing blocks. The successful plan made Copenhagen the European Culture City in 1996. The number of bikes increased to a total of more than 2000 in 1998. It is of interest to note that 38% of users were tourists.

The author of this research also traveled in Scandinavian countries during summer 2006 to learn the Scandinavian bicycle policies and their implementation as case studies. There are three Scandinavian cases: thee Copenhagen case, the Oslo case and the Stockholm case, which are illustrated in Appendix: Cases study in Scandinavian countries. Cases study in Hawaii shows the bicycle case in Hawaii, which is famous for its successful bike-on-bus project, and lovely street facilities of bike racks (its name is “bikebike”).

In 2001 the Maine Department of Transportation presented a report on bicycle tourism that discussed the economic impact of such tourism and made marketing recommendations. The bicycle tourism market is very broad, and includes clear niches. The priorities for cyclists in selecting destinations include: attractive scenery, bicycle-friendly roads or shared use paths, bike oriented services and accommodations, cultural attractions, and features unique to the area. This market comprises cyclists of all ages and abilities, each with well-defined preferences. “Bicycle tourists have strong preferences for different types of experiences, depending on their bicycling skill level and the make-up of their group” (Maine DoT, 2001).

According to Bike On Tour (2003) in Canada and the European Cyclists Federation (2003) in Europe, the characteristics of bicycle tourists in Canada and Europe are as follows: bicycle tourists in Canada are mainly aged 30-55, and are white-collar workers with yearly incomes of over 60,000 U.S. dollars; while European bicycle tourists are in the aged 25-49, and mostly are senior white-collar workers. European bicycle tourists have a high proportion of family touring, use all types of accommodation from camping to luxury hotels, and rely on cafes and restaurants along the cycling route.

Cyclist tourists in Taiwan are found mostly in the age ranges of 16-25 and 36-45. Most of them are unmarried and live in the northern part of Taiwan. Their educational level is postgraduate and the most common occupations are primarily businessmen or students. The average monthly income is approximately 20,000~40,000 NT dollars (Chang et al., 2003).

This study reviewed several investigations on cyclists, which are divided into two groups to facilitate the analysis. These two groups are recreational cyclists and advanced cyclists.

Other reports examined the different types of cycling from different perspectives and are illustrated in Table 2-1 and Table 2-2.

Table 2-1 Types of cycling and the related research

definition of bicycle	as a transport mode	as a tourism supply
purpose	Commute	tourism & recreation
user	Bicycle Commuter	Bicycle Tourist/ Recreational Cyclist
definition of user	By Ritchie, Aultman-Hal, FHWA (after Allen) Gharaibeh etc, Howard & Burns, Shafizadeh & Niemeier	By Ritchie, Simonsen & Jorgenson (after Ritchie), FHWA (after Allen), Lumsdon, Schuett and Holmes
research issues	Route choice Travel behavior User characteristics	Environmental preference Behavior and demand model Marketing and evaluation
methodology	Questionnaire survey GIS and spatial analysis Frequency analysis	Questionnaire survey Factor analysis State preference

Table 2-2 Analysis of significant difference among cyclists

Variables		Recreational Cyclists	Cyclists
attributes and motives	Purpose	Recreation	Exercise/ Cycling
	People traveling with	Family members	People with same interests
equipment and knowledge	Cycling Equipment/ Skills/Safety	City bikes	Mountain Bikes
	Club	None	Yes
experience	Cycling time length	Half day ~a day	A day~ several days
	Cycling frequency	Once~ many time	Frequently
environment preference and facility satisfaction	Factors of expectation before traveling	Traffic environment, recreation facilities and service facilities.	Traffic environment, recreation facilities, local environment and service facilities
	Factors of experience after traveling	Environmental resource, service facilities, local resource and nature resource.	Traffic environment, recreation environment, local environment and service facilities.

The case in Canada is mainly based on strategies by Tourist Transport Management (TTM), which is also known as Resort Community Transport Management. It is also a branch of Transportation Demand Management (TDM). Through cycling and walking, leisure travel choices can be improved and the quantity of automobile traffic in resort areas will be reduced (Victoria Transport Policy Institute, 2003). U.S. Federal Highway Administration (1998) promotes the use of non-automobile vehicles, such as bicycles and walking, to meet the growing environmental pressure to adapt to non-motorized transportation, as well as to meet the needs of health and recreation.

Transportation Demand Management (TDM) occurred in 1980 at the earliest. TDM consists of strategies that result in more efficient use of transportation resources. In the year 2003, the Victoria Transport Policy Institute in Canada produced an "Online Encyclopedia" to increase understanding and implementation of TDM (VTPI, 2003). This Encyclopedia is a comprehensive source of information about innovative management solutions to transportation problems. It provides detailed information on dozens of demand management strategies, plus general information on TDM planning and evaluation techniques.

Related programs about transport demand mentioned the term Tourist Transport Management, which is also named Resort Community Transport Management. This type of management involves improving transportation options for recreational travel and reducing automobile traffic in resort areas. The patterns and needs of tourists are predicable and resort areas often have unique environmental and social features that are particularly sensitive to excessive automobile traffic. Regardless of whether it is an historic city center or a pristine natural environment, Tourist Transport Management preserves the amenities that attract visitors to the area (VTPI, 2003).

These programs deal with strategies to integrate and promote alternative transportation modes into tourist activities, improve transport options, and analyze the disadvantages of driving. The programs include: transit improvements, shuttle service, improvements on travel by cycling and walking, bicycle parking, parking management, serenity in traffic, reduction in speed, wise growth, and so on. TDM can be used to design a benefit evaluation table in order to investigate the value of bicycle facilities' investment.

The case in the U.K. is mainly making progress based on efforts by Sustrans, a sustainable transport charity in the U.K. Sustrans works on practical projects to encourage people to walk, cycle and use public transport in order to reduce motor traffic and its adverse effects. They are working on safe routes to schools and stations, home zones, and other practical responses to the transport and environmental challenges people face. Sustrans' work relies on the generous donations and monthly standing orders of 40,000 supporters, and the support of charitable trusts, companies, the National Lottery, and local authority programs.

Sustrans' flagship project is the National Cycle Network, creating 10,000 miles of routes throughout the U.K. About one-third of the Network is on paths that are free from motor traffic, with the rest using quiet lanes or traffic-calmed roads in towns or cities. Traffic-free sections provide a suitable place for children and new cyclists to practice their skills. Many are also used by walkers, people with disabilities and, in some cases, horseback riders. While the National Cycle Network is ideal for family rides or longer cycling holidays, many people simply choose the routes as an alternative to using the car for local trips to work, school, or shopping. The Network is coordinated by the charity Sustrans and involves hundreds of organizations. These include local authorities, businesses, landowners and environmental bodies.

Sustrans and Northumberland County Council have completed a pilot project to integrate cycling information into online journey planners. The project was funded by the Department of Transport as part of its research program for Transport Direct, a long-term government initiative to provide comprehensive national travel information and booking service over the internet.

The aim of the Northumberland pilot project was to develop and test initial options for the North of England public transport journey planner to provide information on cycle routes for selected journeys via the bus station in Ashington, Northumberland. An experimental link was established between the journey planner and Sustrans' online mapping of the National Cycle Network (NCN) and associated routes in the area.

The resulting system allows users to choose a 'by bicycle' option for journeys via Ashington bus station to or from the outlying settlements of Ellington, Lynemouth, Newbiggin-by-the-Sea and Woodhorn. The journey plan then gives a brief description of the suggested cycle route and connection times for timetabled bus services at Ashington for those continuing their journey by public transport. More detailed information is accessible via a direct link to Sustrans' online mapping at 1:50,000 scale of NCN Route 1 and selected local routes.

The project coincided with the installation of new cycle lockers and stands at Ashington bus station, funded by the Northumberland Local Transport Plan, providing users with safe and convenient storage for their bicycles while they continue their journey by bus. The combined trip planner-cum-interchange facility, known as Bike 2 Bus, is believed to be the first of its kind in the country.

Sustrans and Northumberland County Council have presented the findings of the pilot project, including the feedback from two Bike 2 Bus consultation workshops, to the DoT. It is hoped that the lessons learned will assist in the integration of information on cycling—along with public transport and other travel modes—into the next generation of internet journey planners.

2.3 Methods Applied on Bicycle Research

Published by Cambridge Systematics, Inc. and the Bicycle Federation of America, the "Guidebook on Methods for Forecasting Non-Motorized Travel" divided methods to estimate the demand of bicycle facilities into four parts: Aggregate-Level Methods, Attitudinal Surveys, Discrete Choice Models, and Regional Travel Models. Aggregate-Level Methods include four kinds of methods: Measures of Potential Demand, Comparison Studies, Aggregate Behavior Studies, and Sketch Plan Methods.

Different approaches to research are arranged as follows:

Aggregate Level Methods	Measures of Potential Demand	Clark, D.E. (1997) ITE Estimating Future Bicycle and Pedestrian Trips from a Travel Demand Forecasting Model.
		Deakin, E.A.(1985) ITS Utilitarian Cycling: A Case Study of the Bay Area and Assessment of the Market for Commute Cycling.
		Landies, B., and J. Toole. (1996) BFA/PFA Using the Latent Demand Score Model to Estimate Use.
	Comparison Studies	Before and After
	Aggregate Behavior Studies	Ashley, C.A. and C. Banister (1989) Traffic Engineering and Control Cycling to Work from Wards in a Metropolitan Area

	Sketch Plan Methods	Pushkarev, B., and J.M. Zupan (1971) HRB Pedestrian Travel Demand
		Matlick, J.M. (1996) BFA/PFA If we built it, they will come? (Forecasting Pedestrian Use and Flows)
Attitudinal Surveys		Goldsmith, S.A. (1992) FHWA Case Study No.1: Reasons Why Bicycling and Walking Are Not Being Used More Extensively as Travel Modes.
		Stutts, J.C. (1994) HSRC Development of a Model Survey for Assessing Levels of Bicycling and Walking.
Discrete Choice Models		Wilbur Smith Associates. (1996) RTA, Chicago. Non-Motorized Access to Transit
		Hunt, J.D., and J.E. Abraham. (1997) TRB1998 Influences on Bicycle Use.
		Katz, R. (1996) U of Sydney PhD Demand for Bicycle Use: A Behavioral Framework and Empirical Analysis for Urban NSW.
Regional Travel Models		Cambridge Systematics, Inc. (1994), DOT Short-Time Travel Model Improvements, Travel Model Improvement Program.
		Stein, W.R. (1996) GIT thesis Pedestrian and Bicycle Modeling in North America's Urban Area
		Hunt, J.D., A.T. Browenlee, and L.P. Doblanko (1998), TRB Policy Evaluation Using Edmonton Transport Analysis Model.
		Kagan, L.S., W.G. Sott, and U.P. Avin (1978) FHWA A Pedestrian Planning Procedures Manual.
		DHV Environment and Infrastructure. User's Manual.
		MVA.(1995) Leicester Cycle Model Study.

2.4 Environmental Factor of Cycling

Few studies have examined the environmental preferences of cyclists as summarized in Table 2-3. Those researches have examined environmental factors from the perspective of transportation other than tourism, with the exception of Chang and Chang (2003, 2005, 2007), who examined bicycle tourists in Taiwan and found that cyclists concerned with bicycle lanes, safety, and weather.

Antonakos (1996) conducted a comprehensive literature review about the influence of travel resources and constraints on environmental preferences of cyclists. Antonakos also reviewed documents regarding cycling environmental factors from Efrat (1981) who evaluated a favorable environment for bicycle use in towns, Bovy and Bradley (1986) who established the importance of a limited set of personal and environmental factors in cyclists' route preferences, and Hanson and Huff (1990) who were concerned about the number of cycling facilities within 1km from home.

Broomly (1994) argued that providing routes and facilities for the hire of bicycles is an ideal complement to countryside site provision. Broomly comments that a key to successful provision for cycling is integration into the infrastructure of the site. This includes providing safe and separate routes for cycling, adequate waymarking, safe crossing points, and information for cyclists.

Hopkinson and Wardman (1996) suggested the influences on the propensity to cycle have been hilliness, distance, and safety. Ortuzar, Iacobelli, and Valeze (2000) demonstrated that trip length is a fundamental factor that exerts a significant impact. Hyodo, Suzuki, and Takahashi (2000) analyzed the relationship between cycling behavior and road or sidewalk width. Stinson and Bhat (2003) indicated that travel time is the most important factor in choosing a cycling route.

Krizek (2004) estimated the economic benefits of bicycling and bicycle facilities by identifying a host of related benefits that include: social transportation, user transportation, social, user safety, user health etc. This study argues that bicycle tourism significantly influences the local economy in terms of destination development.

Most studies on cycling in modern societies adopt a transportation perspective, and few studies have examined the relationship between cyclist characteristics and environmental preferences. Waerden (2004) studied cyclists' perceptions and assessments of street characteristics in relation to five specific types. The five characteristics included pavement, on-street parking facilities, priority signs at crossings, bicycle paths and lanes, and bus lanes. The data were obtained via an on-street questionnaire. Cyclists placed greatest emphasis on the pavement of roads followed by bicycle paths and lanes along roads. Cyclists were relatively unconcerned with on-street parking facilities, bus lanes, and priority signs at crossings.

The U.K. DETR (Department of the Environment, Transport and the Regions, 1998) aimed to explore the reasons why increased cycling for leisure purposes has not resulted in more people cycling to work. The research methodology included interviews with over 500 leisure cyclists, non-cyclists, and individuals who regularly cycle to work. Non-cyclists served as a control group. DETR's report argued that, for most people, the decision to use a bicycle purely for leisure purposes is rational since it provides benefits that include health, fresh air, and being a social and relaxing pastime. Gardner (1998) divided cycling history (or cycling lifecycle) into five parts, namely childhood, the break from cycling, the return to cycling, returning only to lapse and return again, and returning to cycling having been influenced by encouraging restarting.

Table 2-3. Factors that Influence the Environmental Preferences of Cyclists

References	Environmental Factors
Bovy & Bradley, 1986 (after Antonakos)	Pavement quality, bicycle facility, traffic, distance/travel time
Efrat, 1981 (after Antonakos)	Traffic, secure parking, climate, terrain
Hanson, & Huff, 1990 (after Antonakos)	Number of establishments within one kilometer from home
Antonakos, 1993 1996	Safety, traffic volume, smooth pavement, scenery, slow traffic, few stops, few hills
Hyodo, Suzuki, & Takahashi	Facility characteristics (road width or sidewalk)
Stinson & Bhat, 2003	Travel time, bike lane or bike path, level of traffic, pavement or riding surface quality, and presence of a bicycle facility on a bridge
Hopkinson and Wardman, 1996	Hilliness, distance, safety
Ortuzar, Iacobelli, and Valeze	Travel length
Chang et al. 2003,05,07	Bike lane, safety, and climate

An extensive literature review was performed in this study to determine which environmental components should be included in the survey of cyclists' preferences. Additionally, components based on recreational development needs and specific to the field of study were then added. Some questions and environmental components were modified during this process, and some components were dropped after the pilot study due to unreliability or ineffectiveness.

2.5 Cycling Difficulty

Thirty years ago, most Taiwanese students used to walk or cycle to their schools but with the current and increasingly heavy road traffic, many parents are justifiably concerned with their children's safety when using either of these two relatively insecure modes of transportation. Due to this problem, the number of students who walk or cycle to school has dropped from 28% to 15% (Chang, 1997).

Walking and cycling to school can provide important opportunities for students to explore their neighborhoods, develop social skills, experience a sense of responsibility and independence, as well as exercise their bodies (GDoT, 2006). In point of fact, the Ministry of Education in Taiwan is drawing up a plan to encourage students to go to school by walking or cycling.

In comparative terms, Denmark was the first European country committed to promote a "Safe Routes to School Program" for children riding their bikes or walking to and from school. That program has spread throughout the rest of Europe, Canada, and, most recently, the U.S. (GDoT, 2006).

For instance, in the United Kingdom, there has been a 50% decline in cycling and more than 90% of students have never cycled to school. In order to tackle this situation the British government began a 21st century cycling proficiency program (entitled "Bikeability Award Scheme"), which started in April 2007 (Cycling England, 2007).

Initially 10 million pounds were budgeted to fund the project with a view to provide students with a realistic experience about cycling practice on the road. The program will also include cycling proficiency courses for 100,000 students, as well as the development of more cycling lanes linked to schools. Local governments are also responsible for providing training programs through road safety bureaus and volunteers. The curriculum includes, among other things, the following elements: cycling skills, emergency braking procedures, considerations when crossing roads, etc. The program includes a written test on traffic laws and a practical cycling exam at the end of the class. (Cycling England, 2007)

The situation is remarkable as not only the government but society as a whole and non-profit organizations are giving careful consideration to the importance of walking and cycling. For example, “Sustrans” (a sustainable transport charity in the United Kingdom) works on a practical program to encourage people to walk, cycle, and use more public transport systems in their daily lives in order to reduce automobile traffic and its adverse effects. The charity is also making an extra effort to promote the “Safe Routes to School Program” by establishing a whole package of practical educational measures to encourage children to get to school by walking and/or cycling. (Bicycle Association, 1994, 1996)

Research undertaken by Gardner (1998) showed that cycling is an integral part of childhood and many positive recollections are involved with it. It serves not only as a means for keeping the body healthy, but also a source of fun and enjoyment, an opportunity to socialize with peers, as well as a context for family outings. The research also revealed that adult respondents tend to link cycling with notions of escapism and freedom.

In the case of the United States of America, the number of students walking or cycling to school has also dropped phenomenally from 66% to 13% (GDoT, 2006). This radical change in habits has led to issues such as greater traffic congestion, increased chemical and acoustical air pollution in the areas surrounding schools, as well as childhood obesity.

In response to these facts, the Federal Highway Administration (FHWA) convened a steering group of bicycle safety experts and, in 1998, developed the first National Bicycle Safety Education Curriculum” This curriculum lists several bicycle safety educational topics and targets audiences of cyclists of different ages and abilities (FHWA, 2002).

At the same time, the Pedestrian and Bicycle Information Center (PBIC) developed a program and checklist to rate a community’s level of “bikeability.” This checklist was divided into five score-grouping categories as follows:

26–30 = a bicycle-friendly community.
21–25 = a good community.
16–20 = conditions for riding are okay.
11–15 = conditions are poor.
10 & below = the worst conditions.

This review has identified the importance of cycling training and examined the relationship between cycling attitudes and behavior, and some of the things being done in some countries to change attitudes and usage patterns; however, it has not addressed obstacles to cycling. In Taiwan, there is a need for policies to provide systematic training on cycling safety but, unlike other countries, the issue presents an additional consideration: while Europe and the United States have focused on training and implementation (Colwell and Culverwell, 2002; IHT, 1998; Hansen etc, 2005; Pucher and Dijkstra, 2003), in Taiwan students simply do not cycle to school. Therefore, this study attempts to investigate the current status of students' perceived cycling difficulties, their ability levels, and impediments to riding their bikes to their schools.

2.6 Conclusions of Literature Review

Exactly how cyclist characteristics and environmental preferences are related has received limited interest. Antonakos (1993, 1996) discussed how travel resources and constraints influence the environmental preferences of cyclists and measured incentives to encourage commuter cycling. Ritchie (1998) and Antonakos (1993, 1996) assessed the cycling environment using rating scales in preference studies. Respondents rated each set of environmental factors on a five point Likert-type scale ranging from "Very important" to "Not important at all".

However, analyzing data from rating scales has some limitations. The data may be biased because respondents are not trained to express their opinions using a scale and, as such, might interpret the scale in different ways. Each respondent has his or her own history of experiences and preferences, thus two respondents may record the same score but express a different weighting or intensity. As such, it is possible that the resulting data violate the assumptions of parametric tests (i.e., the shape of the distribution is normal, as well as the need for homogeneity of variance). Ordered categories are an alternative to rating scales, because assigning equal interval numbers to the ordered categories in this type of study may not be appropriate.

To overcome these limitations, this study employed "Ridit analysis" and produced a ranked list of environmental components. Importance-Performance analysis was applied to examine and assess cycling facilities for government. "Rasch analysis" was applied to explore the difficulties of students cycling to school.

CHAPTER 3 METHODOLODY

A variety of methodologies are applied in this research, including: literature review drawn from bicycle-related publications; focus group surveys and in-depth interviews; and questionnaire surveys. The questionnaire was designed to investigate the differences in cyclist types, environmental preferences, cycling frequencies, cycling purposes, types of cycling equipment owned, and tourism expenditures.

These data are analyzed using various methodologies, including Ridit Analysis and Rasch analysis. The Chi-Square test and K-W test are applied to examine the differences between users. The results will be useful for both central and local governments' development of more bikeway networks and providing cycling facilities with considering cyclist characteristics and their environmental preferences.

3.1 Ridit Analysis

Ridit analysis is used as a conventional method for analyzing data with ordered variables that do not reach the standards of refined measurement systems (i.e., interval or ratio scale data). Since the differences within a survey item or between items using a 5-point Likert-type interval scale might not comply with the linearity and additively assumptions, we transformed the Likert interval scale into an ordered scale and, thus, Ridit analysis was used in this study. The technique of Ridit analysis utilizes a cumulative probability transformation corresponding to the ordered scale within each survey item, which is then used as a reference class (Agresti, 1984; Bradbum, 1969; Bross, 1958; Pouplard, Qannari and Simon, 1997).

"Ridit" is an acronym ('Relative to an Identified Distribution') plus the productive suffix '-it', which denotes a transformation. Bross (1958) explained the details of Ridit as follows: "After simple empirical probability transformations of the variables, Ridit analysis ensures robustness of standard methods…. In an effort to avoid losing information in this way, Ridit analysis was invented, which involves a simple empirical cumulative probability transformation of the entire scale." Based on the above statement, this research adopted the meaning of "empirical distribution" from what is known as the "empirical cumulative probability transformation".

Ridit analysis is an especially useful statistical form for items involving self-ratings on a nominal scale. This measure is a probability transformation based on empirical distribution.

Once the Ridit values for each category of the dependent variables are calculated, individual scores are transformed into the Ridit value for the dependent variable. Differences between groups are considered statistically significant when the upper bound of the confidence interval for the lower Ridit value does not overlap the lower bound of the confidence interval for the higher Ridit value (Bradbum, 1969). According to Pouplard (1997), the steps of Ridit are as follows:

1. First step: choice of an identified distribution

Let $\chi_1, \chi_2, \chi_3, \chi_4, \chi_5$ denote the order categories of the preference scale and let $\{\rho_j ;\ j = 1,2,3,4,5\}$ be a probability function defined on the set $\{\chi_1, \chi_2, \chi_3, \chi_4, \chi_5\}$, namely:

$$\rho_j = \text{Prob}\ (\{\chi_j\}) \text{ and } \sum_{j=1}^{\rho} \rho_j = 1$$

2. Second step: calculate the ridits

With $\{\rho_j ; j = 1,2,3,4,5\}$ chosen as a reference distribution function, the scores $\omega_1, \omega_2\ \omega_3$, ω_4, ω_5 to be assigned respectively to the categories χ_1, χ_2, χ_3, χ_4, χ_5 are given ω_1=0.5 ρ_1

$$\omega_j = 0.5 \rho_j + \sum_{\kappa=1} \rho_\kappa$$

for j=2,3,3,5; thus, ridits are related to the cumulative distribution function associated with the probability function $\{\rho_j ; j = 1,2,3,4,5\}$.

3. Third step: Kruskal-Wallis Test

The Kruskal-Wallis Test is used to test the null hypotheses H_0.

Yang (2008) introduces an $i \times j$ contingency table, with the i^{th} row representing the i^{th} item and the j^{th} column representing the j^{th} ordinal-scale value of agreement with the corresponding items. The value of n_{ij} represents the number of respondents that rated the j^{th} ordinal-scale value of agreement with the i^{th} item. In this study, the smaller ordinal value represents the lower agreement with the "importance" or "satisfaction with the performance" of the corresponding items.

Following the same methodology with different writing notation Yang (2008) introduces a standard distribution amongst the five-point scale values for the population $\{\pi_j; j = 1,2,3,4,5\}$. The r_j represents the average accumulated probability up to the j^{th} ordinal response.

Let $r_1 = \frac{1}{2}\pi_1$, $r_j = (\sum_{k=1}^{j-1} \pi_k) + \frac{1}{2}\pi_j$, $j = 2,3,4,5$.

Where $\pi_j = \frac{n_{.j}}{n_{..}}$, $n_{.j}$ is the number of observations for the specific j^{th} category summed over the 21 items, and $n_{..} = n_{.1} + n_{.2} + n_{.3} + n_{.4} + n_{.5}$. Therefore, the relationship of $r_1 < r_2 < r_3 < r_4 < r_5$ is assured according to the rank of the order, and it leads to the result of $R_{ij} = r_j \pi_{ij}$, in which π_{ij} represents the j^{th} ordinal probability of the i^{th} item.

In order to assess the relative position of the i^{th} item amongst all items, Yang (2008) fixes the i^{th} row and summarize the values of R_{ij} over all five ordinal categories to gain the Ridit value of the i^{th} item (R_i) by using the formula $R_i = \sum_{j=1}^{5} R_{ij}$.

Agresti (1984) expected Ridit values of all items equal to 0.5. Accordingly, the Ridit value of 0.5 will be the threshold to determine whether the corresponding item is relatively important or satisfactory amongst all items.

The scores from the rating scales are transformed to Ridit values (R) for each of the *m* items (environmental component is this study). The R-values denote the relative importance of or satisfaction with the each item. A higher R-value represents a higher level of importance or satisfaction with any given item. A Ridit value of 0.5 represents a neutral opinion. Hence, an R-value greater than 0.5 indicates that a given item is considered by the respondent to be more important (or shows the respondent is more satisfied).

Conversely, an R-value less than 0.5 shows that a given item is considered by the respondent to be less important (or shows the respondent is less satisfied). Thus, a Ridit value above 0.5 indicates greater importance (or satisfaction) to interviewees than a Ridit value below 0.5. Once the R-value for each individual item has been computed, we can then estimate the 95 % confidence interval for each.

The confidence intervals for each item for different groups provide the opportunity to test whether the respondents have different levels of perceived importance and satisfaction among all items.

Furthermore, the Kruskal-Wallis Test is used to determine the differences in importance and satisfaction among items (environmental components) by using the following testing statistic "W":

$$W = \frac{12n}{(n+1)T}\sum_{j=1}^{m} n_j (R_j - 0.5)^2$$

Where "T" called the correction factor for ties, is approximately equal to 1 for large sample sizes (Agresti, 1984). R_j denotes the sample mean Ridit value for the item j, n is the multiplier value of number of respondents by number of items m. Then the statistic W will follow the χ^2 distribution with the degrees of freedom m-1 (i.e., number of items (m) – 1).

The Kruskal-Wallis Test is used to test the null hypotheses H_0, namely that the order of importance does not differ significantly among items. The null hypothesis H_0 is that all the items are equally important; the alternative hypothesis H_1 is that not all the item are equally important. In this study, the null hypothesis H_0 and alternative hypothesis H_1 are as follows:

H_0 ：21 Environmental factors are equally important and without significant difference.

H_1 ：Reject H_0.

3.2 Rasch Analysis

Item response theory (IRT) is a model-based measurement that trait level estimates depend on both persons' responses and on the properties of the item that were administered. Among the various models of IRT, the Rasch model is one of widely applied model (Wu, 2008).

Wu (2008) reviewed Item Response Theory and mentioned that latent variables are assumed as unobservable entities that influence the manifest variables (e.g. test scores or item responses). A measurement theory must provide a rationale that both persons and items should be inferred from behavior.

Item Response Theory was used to estimate the values of these latent variables based on an ordinal scale interval of scores collected in the questionnaires (Johnson & Raudenbush, 2002; Smith & Smith, 2004). Item scores are called "raw scores". In the original response data, the sum of scores across items for each person is referred to as the person raw score, and the sum of the scores across people for each item is called the item raw score. Discussions of item response theory are based on the Guttman scale (Wu, 2008).

Item Response Theory begins with a definition of the latent variable and measures "θ", a variable that is an attribute of respondent *n* and has a unique value for each respondent "θ_n". Each item *i* in the theory require a threshold value of "θ" and have a difficulty of "b_i".

The probability that respondent "n" will give a particular response to item "i" can be represented by the following function, as explained by Birnbaum (1968):

$$P(\theta_{ni}) = c + \frac{d - c}{1 + e^{-a_i(\theta_n - b_i)}}$$

Where:

1. **"c"** represents the lower performance which assumed to be equal to 0
2. "d" represents the upper performance which assumed to be equal to 1
3. "a_i" represents the discriminability of item *i* which is designed to absorb the variability and to create the illusion of precise estimation of person and item values.

Wu (2008) argued that a perfect Guttman scale is hard to achieve, and minor violations are allowed in practice. Therefore *a* is defined to be equal to 1 to keep an invariance across the items, which enables items to be interpreted as measurements of a single variable.

There are three types of Item Response Theory: one-parameter logistic model, two-parameter logistic model and three-parameter logistic model. The simplified one-parameter item response model ($d = 1$, $c = 0$, and $a = 1$) is identical to the probabilistic measurement model developed by the Danish mathematician George Rasch in 1960. Rasch deduced his model from the item response theory and proved that the person and item parameters (θ_n and b_i) are separable, and that item and person raw scores are sufficient statistics to estimate the values of the item and person parameters (Wu, 2008).

Smith and Smith (2004) explained the concept of Rasch model from a simple idea: jumpers jumping fences. The jumpers vary in strength from weak to strong, and the fences are of various heights posing different challenges.

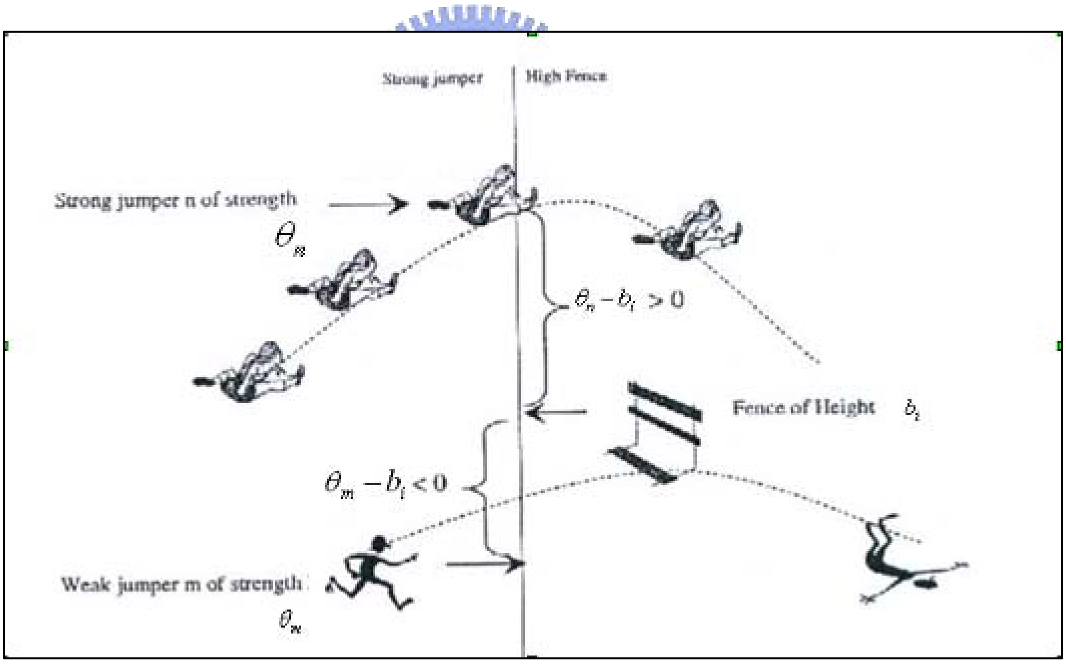


Figure 3-1 Jumper stronger than fence clears. Jumper weaker than fence tumbles.
(Source: Smith and Smith, 2004)

The Rasch model has been intensively used to estimate values on an interval scale from raw ordinal responses in psychometric studies (Massof and Fletcher, 2001). In order to simplify the Rasch model, dichotomous responses were considered. The probability that student "n" will respond to item "i" with an "agree answer (success)" is represented by the following function:

$$P(1|\theta_n, b_i) = \frac{e^{\theta_n - b_i}}{1 + e^{\theta_n - b_i}}$$

The probability that a student "n" will respond to item "i" with "disagree response (failure)" is represented as follows:

$$P(0|\theta_n, b_i) = 1 - P(1|\theta_n, b_i) = \frac{1}{1 + e^{\theta_n - b_i}}$$

The raw score percentage is then converted into an agree-to-disagree (success-to-failure) ratio or odds ratio. The odds ratio reflects the likelihood that a student "n" will respond to item "i" with agree.

$$\frac{P(1|\theta_n, b_i)}{P(0|\theta_n, b_i)} = e^{\theta_n - b_i}$$

Then the log of the odds ratio (logit) is as follows:

$$\ln \frac{P(1|\theta_n, b_i)}{P(0|\theta_n, b_i)} = \theta_n - b_i$$

The person and item parameters in the case of dichotomous responses can be estimated from the response odds ratios in the data set using the formulation shown as above. In addition to dichotomous responses, the Rasch model has been modified to be applicable to polytomous rating-scale instruments, such as the five-point Likert scale (Andrich, 1978; Masters, 1982).

In 1978 Andrich modified the Rasch model to make it applicable to polytomous rating scale data. In the modified Rasch model the log odds of the probability is that a person responds in category x for item i , compared with category $x{-}1$, as a linear function of the person parameter θ_n and the relative parameter of category x, namely b_{ix}, for item i:

$$\ln\left(\frac{P_{nix}}{P_{ni(x-1)}}\right) = \theta_n - b_{ix} \qquad \text{(a)}$$

Following Andrich's modification of the Rasch model for a polytomous response, two types of formulation are widely applied in assessing the values of item and person parameters: rating scale model and partial-credit model. The former is used only for instruments in which the definition of the rating scale is the same for all items, the later is used when the definition of the rating scale differs from one item to another (Wu, 2008).

In Andrich's modified Rasch model, each item "i" has its own threshold F_{ix} for each category "x", therefore, $b_{ix} = b_i + F_{ix}$, and Equation (a) becomes Equation (b).

$$\ln\left(\frac{P_{nix}}{P_{ni(x-1)}}\right) = \theta_n - b_i - F_{ix} \quad \text{(b)}$$

3.2.1 Parameter estimation of the Rasch model

According to Wu (2008), based on different statistical assumptions, there are several approaches for estimating the parameters of Rasch model. The joint maximum likelihood (JML) estimation is a relative simple and effective way, which is also the core technique of the related computer programs: the WINSTEPS and FACETS.

3.2.2 Model fit and reliability

The Rasch model provides a mathematical framework against which test developers can compare their data. This model is based on two hypotheses:

1. Unidimensionality which means useful measurement involves the examination of only one student attribute at a time;
2. Local independence.

Bond and Fax (2001) argued that "Student" and "Item" performance deviations from the "fit" can be assessed and the item's "Difficulty" and "Student Ability" are estimated on a logit scale. There are two "fit" statistics in the Rasch model: infit and outfit.

1. The infit statistic is a weighted standardized residual.
2. The outfit statistic is an average of the standardized residuals.

Standardized fit statistics (Zstd) must be within the 95% confidence interval to be considered as having acceptable values between -2.0 and +2.0 standard deviations from the mean; however, Oreja-Rodriguez and Yanes-Estevez (2007) suggested that the range between -3.0 and +3.0 is also acceptable.

Therefore, this study applied the Rasch model to investigate the difficulty of students cycling to school and their cycling ability.

Rasch model is applied to investigate the difficulties of students cycling to school in this study. Following the methodology of Massof and Fletcher (2001), the variables selected to represent these obstacles are latent and inferred from the subjects' answers and the observers' judgments about the subjects' behavior. An 11-item questionnaire was used to collect data based on the students' ratings of items using a five-point Likert-type Scale (5 = Strongly Agree, 4 = Agree, 3 = Neutral, 2 = Disagree, and 1 = Strongly Disagree).

CHAPTER 4 RESEARCH TOPICS

There are a few important issues that Hsinchu Technopolis area is facing, such as highest motor vehicles ownership relating to climate change, energy consumption, rising environmentalism and so on. In order to explore alternative solutions to this situation this thesis is organized into different research spheres as followed:

Chapter 4.1 reflects, from the geographical point of view, the preference and satisfaction of cyclists in two compared levels: National (Taiwan) and local (Hsinchu Technopolis). By using surveys collected in these two levels Ridit analysis is applied to get conclusions about the differences between bicycle tourists in one of the national scenic bikeways and recreational cyclists in one of the local Hsinchu Technopolis' bike lanes.

Regarding the same variable (the preference and satisfaction of cyclists) Ridit analysis is also applied to chapter 4.2 by focusing specifically in the Hsinchu Technopolis area. In this case two different groups of users are compared: High-Tech workers of the Hsinchu Science-Based Industrial Park (HSIP) and Non-High Tech workers.

At the same time chapter 4.3 keeps on researching Hsinchu Technopolis area by adding further elements to the study: the obstacles suffered by students cycling to school and the Rasch analysis as measurement method to get conclusions.

4.1 Comparisons Between the Differences of Bicycle Tourists and Recreational Cyclists

4.1.1 Problems and Hypotheses

There are two kinds of recreational bikeways in Taiwan: bikeways located in national scenic areas and built by the central government, and bikeways located in local areas and built by local governments. This study focused on the different preferences of recreational cyclists using these two kinds of bikeways. The two types of users differ in terms of the three "As", namely Accessibility, Activity purpose, and Attraction.

Accessibility denotes that bicycle tourists using national scenic bikeways come from all over the Island, while recreational cyclists using local bike lanes come from local areas. Activity purpose denotes that bicycle tourists using national scenic bikeways are motivated by sightseeing, while recreational cyclists using local bike lanes are motivated by leisure and exercise. Attraction denotes that bicycle tourists using national scenic bikeways are seeking tourist attractions, while recreational cyclists using local bike lanes are seeking high quality bicycle facilities.

Although Taiwan has been recognized as one of the most promising countries for bicycle manufacturing, where nearly 92% of total sales are for export, and only 8% are sold domestically. However, bicycle usage as a transportation mode in Taiwan has always been an issue (Chang and Hsieh, 2004). Since scenic areas have great potential for promoting recreational cycling using national bikeways and local bike lanes, this study examined two hypotheses defined as follows:

The first hypothesis is as follows: National scenic bikeways attract bicycle tourists from all over the country, who are motivated mainly by the desire to enjoy attractions and landscapes. Bicycle tourists are motivated by sightseeing more than the desire to cycle. While local bike lanes provide opportunities to cycle for leisure and exercise. Cyclists from local areas are mainly motivated by the desire to cycle. The second hypothesis is that users of the two types of cycle amenities differ markedly in their environmental preferences.

This is an original study investigating the environmental preferences of bicycle tourists and recreational cyclists in Taiwan. Comparing bicycle tourists using national scenic bikeways and recreational cyclists using local bike lanes, this study explored significant differences between the preferences of the two groups. This study used questionnaire data and Ridit analysis to examine two bikeway systems implemented separately by central and local governments. The analytical results will be useful in establishing bikeways by both the central and local governments.

Transportation and tourism development are closely related. Transportation links tourists with their destination regions. Many tourism articles have discussed transport, and many authors have studied the importance of efficient transport to successful tourism development (Prideaux, 2000). However, few studies have considered the significance of transport mode as an environmental or economic influence on destination development.

This study argues that traveling to prefer destinations by high speed transport systems (for example car, coach, etc) is efficient for tourists. However, if tourists get to the destination and get around the destination after arriving still using a high speed transportation mode, it is not environmental friendly and does not allow for full enjoyment of the tourist attractions.

On the other hand, if tourists arrive at their destinations and use a low speed transportation mode (such as walking or cycling), it is environmental friendly and tourists can enjoy the details of the attractions. The relationship between transportation and tourism development is inseparable and influences the local and national economy. Figure 4-1 illustrates the role of transportation systems in destination development. Figure 4-2 illustrates the structure of cycling development in Taiwan.

The Taiwanese government usually stresses environmental factors, such as civil engineering work and landscape designs, when building national bikeways and local bike lanes. However, the government has neglected the characteristics of recreational cyclists and their environmental preferences. Consequently, both bicycle tourists' and recreational cyclists' needs cannot be further satisfied, and many public facilities are left unused and wasted (Chang, 2003). Therefore, this study investigates environmental preferences of recreational cyclists in Taiwan in order to provide appropriate cycling facilities to cyclists from the aspect of marketing segmentation.

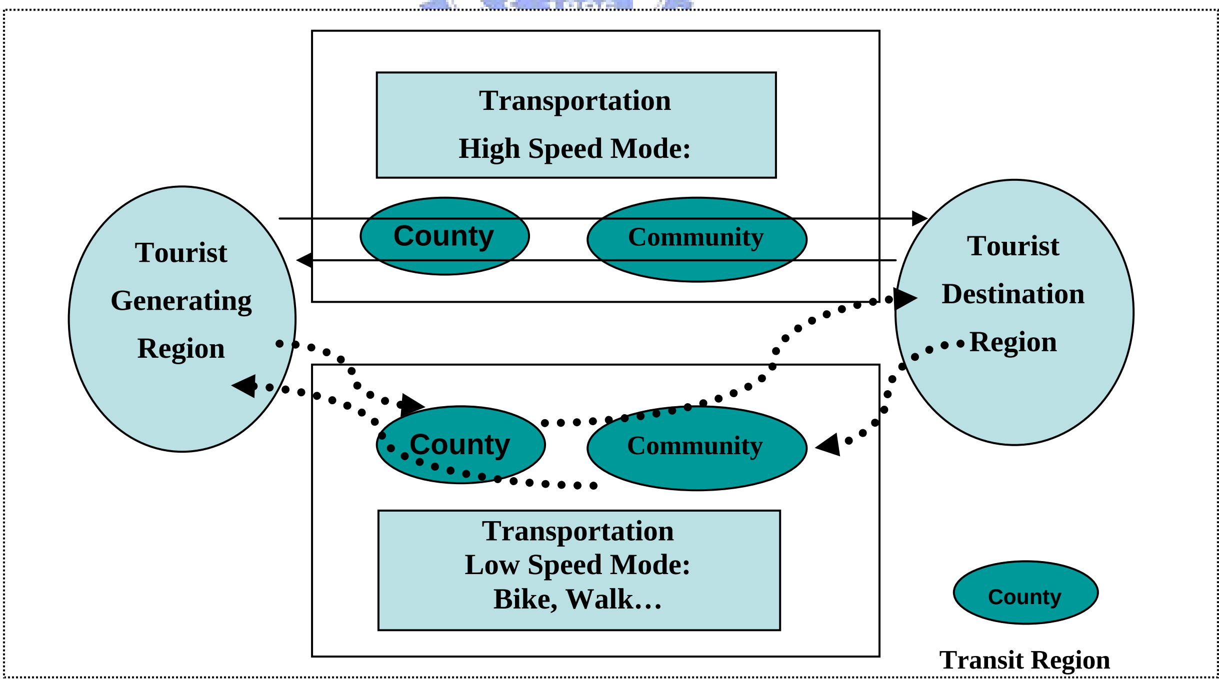


Figure 4-1 Role of transportation systems in destination development

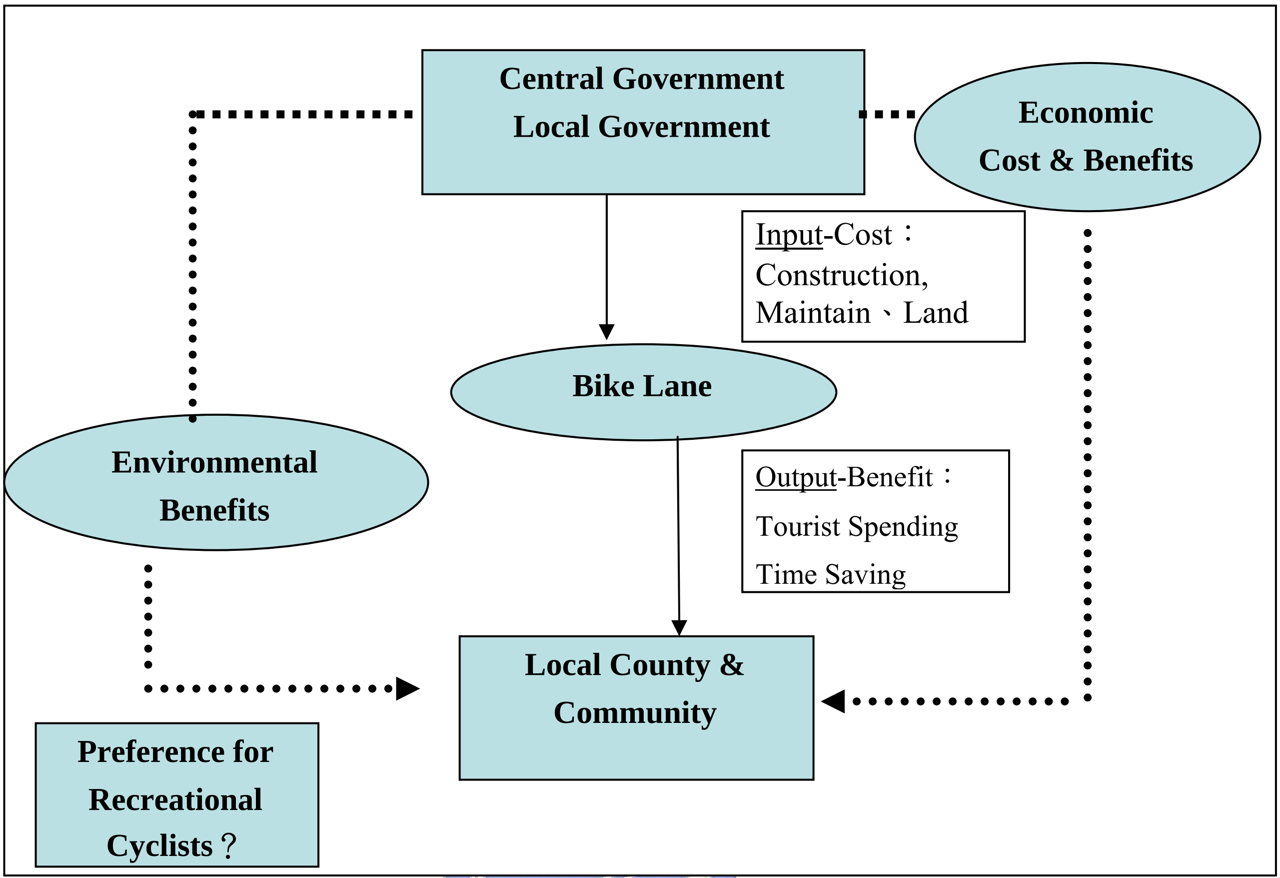


Figure 4-2 The structure of cycling development in Taiwan

The former case is a 201.66 km-long bikeway network produced by the National North Coastline Scenic Administration, and the route planning of the project was completed in 2003. The National North Coastline Scenic Region located at northern Taiwan is known as the "crown coast" owing to its natural beauty, and stretches 57 kilometers. The National North Coastline Scenic Region has a local population of 200,000, and an annual total of 1.6 million tourist visitors. The authors were involved in planning the bikeway network on behalf of the National Scenic Region Administration (Chang and Chang, 2004).

The latter case is a bikeway system running alone the coastal area of Hsinchu city, which was planned by the Hsinchu City Government since 2002. This 17 km-long coastal bikeway network was completed at the end of 2005, and involves an investment of 5.3 billion NTD over three consecutive years. The development of this coastal bikeway is a priority of the city government. With a local population of 400,000, Hsinchu City is famous for the Hsinchu Scientific Industrial Park, which is a center of development for science and technology industries in Taiwan. Besides improving the investment environment, the city government is also working enthusiastically to improve living quality and promote coastal tourism. The two study cases are compared as follows.

Table 4-1 Comparison of the two cases

Administration	National North Coastline Scenic Administration	Hsinchu city government
Area	The National North Coastline Scenic Region	Hsinchu city coastline
Coastline length	57km	17km
Bikeway length	201.66km	17km
Cycling attractions	Mountain, coast	Coast
Bikeway construction cost	40 million NTD	5.3 billion NTD
Grades	0~5%, 5~8%, 8%~	0~5%, 5~8%
Local population	200,000	400,000
Tourists	1,600,000	170,000

This study focuses on recreational cyclists touring the National North Coastline Scenic Region and Hsinchu coastline. Cyclists touring the two study areas separately were divided into two groups: bicycle tourists using national scenic bikeways, and recreational cyclists using local bike lanes. The two groups were compared in terms of their characteristics and preferences.

In the case of the national scenic bikeway, questionnaires were administered on two weekends in March and April 2004, during which bicycle tourism activities were held by the Taiwan Tourism Bureau. Pre-testing had already been conducted in February of the same year. Respondents to the questionnaires were selected by random sampling among attendants.

In the latter case of the local bike lane, questionnaires were administered on a weekend in September 2005, during which a bicycle recreational event was held by the city government. Pre-testing had already been conducted one week previously. Respondents to the questionnaires were selected by random sampling among attendants.

The author participated in the activities and issued questionnaires to bicycle tourists and recreational cyclists. Interviewees were administered face-to-face questionnaires that took 5-10 minutes to complete. The responding feedback percentage was fairly high. Almost all the interviewed cyclists completed their questionnaires and provided their comments on facility design. The questionnaires were retrieved immediately upon completion. One hundred and twenty-two valid questionnaires were obtained in the former case, and one hundred and five valid questionnaires were obtained in the latter case.

Based on their responses to the questionnaire, as well as their experience with and knowledge of cycling and their equipment, the respondents interviewed at the national scenic bikeway were divided into advanced cyclists (48 respondents) and recreational cyclists (74 respondents).

Based on their responses to the questionnaire item asking whether or not it was their first time cycling in the Hsinchu coastal bike lane, cyclists using the local bike lane were divided into events cyclists (60 respondents) and leisure cyclists (45 respondents). Figure 4-3 illustrates the sampling result.

The data is analyzed using the methodology of Ridit Analysis, and the Chi-Square test is applied to test the differences in environmental preferances between bicycle tourists and recreational cyclists. Ridit analysis is designed to assist in analyzing data involving ordered variables that do not reach the standards of refined measurement systems.

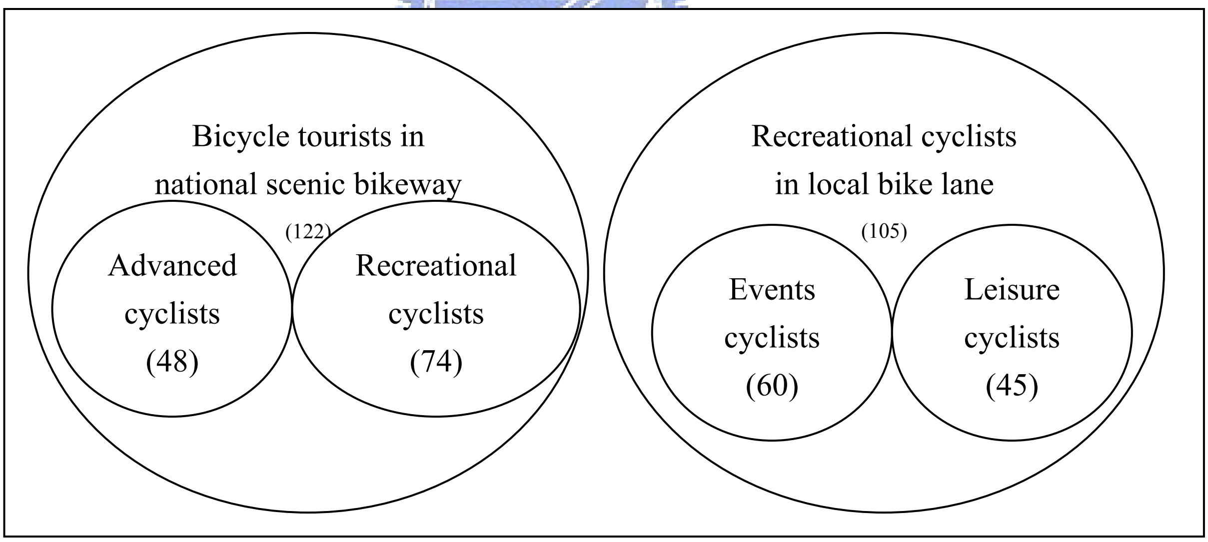


Figure 4-3 The sampling result

The questionnaire collected seven categories of information items from the sampled cyclists. These categories of items include the social economic characteristics, traveling behavior, owning cycling equipment, experience of using the cycling equipment, expectations before the trip, actual trip experience, and their opinions after their cycling trip.

Moreover the survey results are divided into two parts. First, the statistical results reveal a clear distinction between bicycle tourists on national bikeway and recreational cyclists on local bike lane, which corresponds to hypothesis 1. Second, the environmental factors in "expectation before the trip" are used to conduct the Ridit Analysis, testing the differences in the environmental preferances of bicycle tourists in national bikeway and recreational cyclists in the local bike lane, which corresponds to hypothesis 2.

4.1.2 Data Collection

The statistical analysis reveals that the basic demographic information about cyclists is not the same for the two groups. Analysis of cyclists characteristics are illustrated as follows:

Bicycle tourists on the national scenic bikeway are aged 30-34 (24.6%), male (60%) and female (40%), married with children (52.5%), living in the northern part of Taiwan (93%). Most of them have college and university education (66.4%). Their occupations are mostly business or service related (40.2%). The average yearly family income ranges from 540-740 thousand NT dollars (29.5%).

Recreational cyclists on local bike lanes are aged 31-40 (48.7%), male (58%) and female (42%), married with children (61%), living in Hsinchu city (75%). Most of them have college and university education (87%). They are mostly working in the science industrial park (25.6%), secondary occupations are business or service related (20.5%). The average yearly family income is ranging from 540-740 thousand NT dollars (29%).

Bicycle tourists using the national scenic bikeways seek touring in their leisure time and consider cycling to be part of a tourism trip. Thus, the bicycle tourists consider cycling "a means to the end of tourism". Bicycle tourists resemble numerous other tourists, seeking a variety of experiences, while overall seeking more adventure than average tourists.

Recreational cyclists using local bike lanes seek cycling itself rather than sightseeing. That is, recreational cyclists consider cycling to be the main objective of the trip and the sole means of transportation for completing the trip. Thus, the recreational cyclists consider cycling "to actually be the end". Table 4-2 shows the comparisons between the two groups.

Table 4-2 Comparisons between the demographic information of cyclists

	Cycling tourists using national scenic bikeways	Recreational cyclists using local bike lanes
Age	30-34(24.6%)	30-34(23.7%) 35-39(25%)
Gender	Male (60%) Female (40%)	Male (58%) Female (42%)
Marriage status	Married with children (52.5%)	Married with children (61%)
Education	College and university education (66.4%)	College and university education (87%)
Average yearly family income	540-740 thousand NT dollars (29.5%).	540-740 thousand NT dollars (29%)
Occupation	Business or service related (40.2%).	Business or service related (20.5%) Working in science park (25.6%)
Come from	Northern Taiwan (93%)	Hsinchu city (75%)
Activity purpose	Touring and sightseeing (48.4%)	Cycling, leisure and exercise (73.7%)

Both groups are predominantly aged 30-39, and are dominated by white-collar workers with annual family income exceeding 500 thousand NT dollars. Both groups engage a lot of family touring with children, and are well educated.

However, the two groups differ significantly in accessibility and activity purpose. Bicycle tourists using the national scenic bikeway were predominantly from northern Taiwan, drove up to three hours to reach the national coastline scenic region, and are motivated by the desire to tour the beautiful coastal areas, while simultaneously enjoying cycling.

Recreational cyclists using local bike lanes came from local areas less than one hour away by car, and thus enjoy much easier access than the former group. Their purpose is leisure and exercise in the local coastal area. The analytical results supported hypothesis 1.

4.1.3 Different Environmental Preferences of Cyclists

This section analyzes the environmental preferences of bicycle tourists using national scenic bikeways and recreational cyclists using local bike lanes. Using a five point Ordinal Scale— 1 = Very Important, 2 = Important, 3 = No Opinion, 4 = Not Important, 5 = Not Important At All—21 environmental factors were rated to demonstrate how much they emphasized those factors. Therefore, Ridit analysis is performed to examine whether the importance of different environmental factors differ significantly. Hence, the null hypothesis (H_0) states that all 21 environmental factors are equally important for cycling; and the alternative hypothesis (H_1) states that all 21 environmental factors are not equally important. Furthermore, the hypotheses are examined for bicycle tourists using national scenic bikeways and recreational cyclists using local bike lanes separately.

The differences between the recognition of the importance of factors and the factors themselves are further analyzed and tested using the Chi-Square test. Ridit analysis is further performed to clarify the differences in order and class. Moreover, the cumulative probability score is used to calculate the Ridit value for each group, as listed in Tables 4-3 and 4-4. The Ridit values and their 95% confidence intervals of different environmental factors for both cyclists are also shown in these two tables, respectively. This study uses the Kruskal-Wallis Test to test the null hypotheses (H_0), namely that the order of importance does not differ significantly among environmental factors so far as the two groups of cyclists are concerned.

Table 4-3 Ridit values for bicycle tourists using national scenic bikeways

Order of importance	Factors	Ridit value
1	Safety	0.2262
2	Tourism attraction	0.3015
3	Challenging terrain preferred	0.3377
4	Rest place	0.3964
5	Restroom	0.4050
6	Scenery and greenery	0.4092
7	Low flow of traffic	0.4216
8	Bike route length long enough	0.4281
9	Accommodation	0.4514
10	Weather and climate	0.4538
11	Signage and interpretation	0.4852
12	Cafe and restaurant	0.4853
13	Pavement quality	0.5375
14	Bicycle map	0.5533
15	Bike path	0.5536
16	Convenience store	0.5618
17	Racks and locker provided	0.6489
18	Bike rental provided	0.6837
19	Touring activity for cycling	0.6940
20	Friendly residents	0.7136
21	Flat terrain preferred	0.7513

Table 4-4 Ridit values for recreational cyclists using local bike lanes

Order of importance	Factors	Ridit value
1	Safety	0.2590
2	Low flow of traffic	0.3788
3	Bike path	0.3812
4	Restroom	0.4080
5	Tourism attraction	0.4330
6	Bicycle map	0.4400
7	Rest place	0.4628
8	Signage and interpretation	0.4649
9	Pavement quality	0.4928
10	Racks and locker provided	0.4969
11	Challenging terrain preferred	0.5061
12	Weather and climate	0.5240
13	Bike rental provided	0.5435
14	Scenery and greenery	0.5483
15	Bike route length long enough	0.5603
16	Cafe and restaurant	0.5608
17	Touring activity for cyclists	0.5615
18	Flat terrain preferred	0.5626
19	.Friendly residents	0.6004
20	Convenient store	0.6435
21	Accommodation	0.7079

(Note: While the scale anchors for this data collection remained the same (i.e., Very Important to Not Important At All) the associated scale values were reversed. More specifically, the method introduced for the data reported in Chapter 3 had ratings of 5 = Very Important...1 = Not Important at All, whereas on the questionnaire used for this data collection the scale was reversed so that 1 = Very Important…5 = Not Important at All. Given this, the interpretation of the Ridit values for this section will be the opposite of that described in Chapter 3.)

The value of the χ^2 distribution with df = 20 at the significance level of $\alpha = 0.05$ is χ^2 (20) = 31.14. Hence H_0 for the bicycle tourists and recreational cyclists are both rejected. This finding demonstrates that the two groups of cyclists significantly differ with respect to their recognition of the importance of the 21 environmental factors.

Where R_j represents the relative position of importance for the j^{th} environmental factor. The lower R_j value denotes the higher one on the consentient level to interviewees' environmental preference. The value of 0.5 denotes no opinion. A lower R_j value than 0.5

implies a higher order of importance for the j^{th} environmental factor. Otherwise, a higher R_j than 0.5 implies a lower order of importance. Thus, factor with Ridit value lower than 0.5 suggests that the factor is more important to interviewees than a factor with the Ridit value exceeding 0.5.

Regarding cycling environmental factors, bicycle tourists using national scenic bikeways consider safety, tourism attraction, and challenging terrain to be most important, and consider flat terrain, friendly residents, and touring activities for cycling as least important.

Recreational cyclists using local bike lanes regard safety, low flow of traffic, and bicycle paths as being most important, and view friendly residents, convenient stores and accommodations as least important.

The two groups share a common concern with safety. However, other beliefs are totally different, for example, beliefs regarding which environmental factors are important and which are unimportant. This finding correlates with the hypothesis that the two groups of cyclists have different preferences regarding environmental factors. Table 4-5 compares the top three important and unimportant factors.

Table 4-5 The comparison between important and unimportant factors of two groups

	The most important factors	The least important factors
Bicycle tourists in national scenic bikeway	1.safety 2.tourism attraction 3.challenging terrain	1.flat terrain 2.friendly residents 3.touring activities for cycling
Recreational cyclists in local bike lane	1.safety 2.low flow of traffic 3.bicycle paths	1.friendly residents 2.convenient stores 3.accommodations

This study explored preferred environmental factors by different groups. Common concerns of the two groups (ridit values lower than 0.5) are as follows: safety, low flow of traffic, tourism attraction, signage and interpretation, rest places, and restrooms.

Bicycle tourists' concerns only are challenging terrain, bike route length long enough, accommodations, cafes and restaurants, weather and climate, scenery and greenery; while recreational cyclists' concerns only are bike paths, bicycle maps, pavement quality, bike racks, and lockers.

Both groups are not concerned with the following (ridit values higher than 0.5): flat terrain, touring activities, friendly residents, bike rental, and convenience stores. Table 4-6 illustrates the investigative results of important environmental factors.

Table 4-6 Study findings of preferences environmental factors

To whom it will be concern	Environmental factors
Common concern of two groups	Safety, low flow of traffic, tourism attraction, signage and interpretation, rest places, restrooms
Bicycle tourists using national scenic bikeway concern only	Challenging terrain preferred, bike route length long enough, accommodations, cafes and restaurants, weather and climate, scenery and greenery
Recreational cyclists using local bike lane concern only	Bike path, bicycle map, pavement quality, bike racks and lockers provided
Both groups are not concerned	Flat terrain preferred, touring activities for cycling, friendly residents, bike rental provided, convenient stores

4.1.4 Results and Findings

This study investigates environmental preferences of recreational cyclists in Taiwan. A post-occupancy evaluation of the present cycling routes is conducted first. Recreational cyclists' needs are further explored and differences in the preferences of bicycle tourists using national scenic bikeways and recreational cyclists using local bike lanes are further analyzed.

Based on planning and analytical results, we concluded that the two groups of cyclists in Taiwanese scenic areas are bicycle tourists and recreational cyclists. These two groups differ significantly in their environmental preferences. The two groups share common concerns with safety, low flow of traffic, tourism attraction, signage and interpretation, rest places, and restrooms.

Owing to the fact that both bicycle tourists and recreational cyclists contribute to local economies, the government in Taiwan should carefully plan environmental facilities when cycling networks are going to be established; such as bike paths, service facilities, and a combination of landscape and tourism, to satisfy the present recreational cyclists' needs and attract potential tourists who have never before been engaged in bicycle touring.

Bicycle tourists are more concerned with variable and challenging terrain and abundant tourism resources, and moreover have a propensity for tourism vacations. Consequently, planning for bicycle tourists should focus on factors such as tourist attractions and accommodations.

Recreational cyclists using local bike lanes value bicycle services and environmental facilities around scenic areas more than bicycle tourists. Therefore, to meet the needs of recreational cyclists, sophisticatedly designed bicycle lanes or bicycle paths should be set up to give cyclists rights to road space and to minimize distractions from automobiles. Consequently, planning for bicycle lanes or bicycle paths for recreational cyclists should focus on pavement quality, signage, and infrastructure.

Developing a strategy for addressing the common concerns of bicycle tourists and recreational cyclists of traffic management is the main priority, followed by tourism planning, then landscape design, and finally infrastructure construction.

In developing a bicycle tourism strategy for bicycle tourists using national scenic bikeways, cycling route planning is the first priority, followed by devising bikeway construction techniques, and finally improving long-stay facilities, such as accommodations.

In developing a recreational cycling strategy for recreational cyclists using local bike lanes, bicycle facilities are the first priority, followed by bicycle map design and availability. Table 4-7 lists the strategies identified based on the findings of this research.

This study solely distinguishes between bicycle tourists using national scenic bikeways and recreational cyclists using local bike lanes. Differences between recreational cyclists and non-cycling tourists will be further investigated to identify promising cyclists. By assessing future needs, the number of bicycle tourists and recreational cyclists who are needed can be determined. Doing so will provide all levels of government with more clear and specific user needs and can also help in evaluating investment potential.

Table 4-7 Strategies developed based on the research findings

Strategy for addressing the common concern for bicycle tourists and recreational cyclists	1.Traffic management 2.Tourism planning 3.Landscape design 4.Infrastructure construction
Strategy for bicycle tourists using national scenic bikeways	1.Cycling route planning 2.Bikeway construction technique 3.Long-stay facility
Strategy for recreational cyclists using local bike lanes	1.Bicycle facility 2.Bicycle map design

Future studies should identify the primary target markets for the bikeways and bike lanes in both national scenic areas and local areas, as well as identifying potential barriers to individuals taking cycling tours on bikeways and bike lanes, establishing the needs of target markets in terms of information regarding bikeways, bike lanes, and related facilities, and assessing how to market the bikeways and bike lanes to their target markets.

4.2 The Preference and Satisfaction of High-Tech Workers and Non High-Tech Workers

This study tried to investigate two groups of recreational cyclists' environmental preferences for, and satisfaction with, existing cycling facilities in a technopolis. An in-depth examination of between-group differences in demand for recreational cycling was done and based on the personal characteristics, cycling experiences, and cycling resources. An omnibus test was conducted to examine whether there were any differences between the two professional groups in terms of their environmental preferences for cycling facilities. Additional analyses were conducted to examine the importance that cyclists placed on environmental factors, as well as their levels of satisfaction. Significant between-group differences were found regarding the environmental preferences and significant within-group differences were also found regarding the importance ratings of the environmental components, as well as their ratings of satisfaction with those components. The results provide valuable information for evaluating the efficiency of governmental resource allocations and, by extension, providing guidelines for an appropriate cycling policy when constructing recreational cycling facilities.

The newly established 17 km of dedicated bike lanes along Hsinchu's beautiful coastline cost about NTD 5.3 billion. Considering the amount of the investment, the needs of cyclists must be understood to assess whether the government's limited resources are allocated properly and for maximum advantage.

4.2.1 Problems and Hypotheses

To overcome those limitations defined in chapter 2, this study investigated cycling preferences by employing Ridit analysis, and produced a ranked list of environmental components. Then an Importance-Performance Analysis was applied to examine the cyclists' preferences for environmental components and assess cycling facilities by analyzing the cycling components.

Importance-Performance Analysis has been utilized by marketers as a mechanism for examining the desirability of product attributes (O'Sullivan, 1991). The analysis is especially valuable in outdoor recreation studies. This research is based on the hypothesis that cyclists' assessments are the result of both cyclists' determination of the importance of various environmental components coupled with their satisfaction with the existing facilities.

This study explores the personal characteristics, cycling experience, and cycling resources of high-tech workers (those who work in the HSIP or in related enterprises), and compares this group with other (non-high-tech) workers. In terms of the cycling environment, preferences for and satisfaction with cycling facilities between the two groups were compared to determine any significant differences. Their rankings of environmental components and levels of satisfaction were then compared. This study focuses on providing recommendations for an appropriate policy on recreational cycling facilities, as well as for the planning of Technopoles. Table 4-8 Shows those environmental components which were considered in this study

Table 4-8 Environmental components investigated in this study

Environmental components	Related reference studies
Q1.Bike route long enough, complete and continuous	Antonakos (1993, 1996) Ortuzar, et al. (2000)
Q2.Bike path wide enough for safety and comfort	McClintock and Cleary (1996) Hyodo, et al. (2000)
Q3.Gentle slopes and curve / ease of ride	Efrat (1981) Antonakos (1993, 1996)
Q4.Rough slopes, path offering variety and challenge	Hopkinson and Wardman (1996)
Q5.Pavement quality (smooth, without bumps/holes)	Bovy and Bradley (1986) Antonakos (1993, 1996)
Q6. Pavement colorful and of diverse materials	Chang and Chang (2005)
Q7.Good weather	Efrat (1981) Ritchie (1998)
Q8.Area of outstanding natural beauty (AONB)	Ritchie (1998) Antonakos (1993, 1996)
Q9.Bike trail passes beautiful/ famous attractions	Chang and Chang (2005)
Q10.Rest places and view points	Recreational development needs
Q11.Parking area for cars and bicycles	Efrat (1981) Waerden (2004)
Q12.Greenery / shade trees	Recreational development needs

Q13.Signage system and map	Bromley (1994) Antonakos (1993, 1996)
Q14.Tourist interpretation system	Bromley (1994)
Q15.Restrooms and shower facilities	Krizek (2004)
Q16.Bike path (right-of-way separate from roads)	Bromley (1994) Stinson and Bhat (2003)
Q17.Reasonably priced bike rental system	Specific to the study area
Q18.Cafe, restaurant, and convenience store	Recreational development needs
Q19.Cleanliness and environment management	Recreational development needs
Q20.Accessibility	Hanson and Huff (1990)
Q21.Government efforts and promotion	Jackson and Ruehr (1998)

The research design included five categories of variables: personal characteristics, level of cycling experience, cycling resources, environmental preferences, and environmental evaluation (satisfaction with cycling facilities), which are defined as follows:

Personal characteristics include gender, age, place of residence, marital status, and profession (i.e., high-tech vs. non-high-tech). Cycling experience includes cycling motivation, cycling frequency, days for cycling, and duration of cycling. Cycling resources include bicycle ownership, type of bike, equipment/accessories, and transportation to site of cycling. Environmental preferences refer to the pre-cycling survey (i.e., cyclists' ratings of the general importance of the environmental components). Environmental evaluation refers to the post-cycling survey (i.e., the respondents' levels of satisfaction with the existing bike lanes in terms of the same environmental components rated for importance).

Two hypotheses are proposed to explain the relationships among the variables:

1. High-tech workers differ significantly from non-high-tech workers in regard to personal characteristics, cycling experience, and cycling resources.
2. The two groups differ significantly in terms of environmental preferences for and satisfaction with existing cycling facilities and, more specifically, in the order of importance in which they rank environmental components and their levels of satisfaction in their environmental evaluation.

4.2.2 Data Collection

The first step in undertaking this research was to generate a list of environmental components for consideration. The list of 21 environmental components was then developed into a questionnaire for cyclists. The sample for this investigation was comprised of cyclists using the 17 km Coastal Bike Lane of the Hsinchu technopolis. Cyclists were approached as a convenience sample. The authors traveled to the site and randomly provided questionnaires to recreational cyclists, as well as conducting in-depth interviews over more than a ten-day period, including both weekdays and weekends. Sampling was conducted in the late afternoon in order to catch the many cyclists who avoid the midday sun. The completion response rate was high; almost all the interviewed cyclists completed their questionnaires and offered comments on cycling facilities. It is acknowledged that using an intercept approach to sampling can provide skewed data, which is another reason why using a non-parametric approach for analysis was justified.

Formal questionnaires were administered from March through May, 2005, and from January through February, 2006. A two-stage survey on expectations for and satisfaction with the environmental components was conducted. In the first stage, before cycling, the cyclists ranked the 21 environmental components in terms of their importance using a five-point Likert-type scale (ranging from “Very important” to “Not important at all”). In the second stage, following the completion of the cycling activities, the cyclists ranked the identical set of environmental components according to the cyclists’ levels of satisfaction with the existing facilities using another five-point Likert-type scale (ranging from “Very satisfied” to “Very dissatisfied”). The questionnaires were completed face-to-face with the authors and were retrieved immediately upon completion.

A total of 345 valid questionnaires were obtained, of which 125 respondents were categorized as high-tech workers and the remaining 220 respondents assigned to the other (non-high-tech worker) group. If a respondent filled out the first questionnaire but was not available to fill the second, then his or her responses were discarded. Thus, all 345 questionnaires utilized for analysis were surveys collected from each respondent both before and after cycling.

The two groups were compared in terms of their personal characteristics, cycling experience, cycling resources, and cycling preferences for, and satisfaction with, existing facilities. The data analysis was divided into three stages. In the first stage, descriptive statistics and Chi-Square tests were applied to analyze the cyclists' characteristics, levels of experience, and resources. In the second stage, the data was analyzed using Ridit Analysis, after which the Kruskal-Wallis test was applied to conduct an omnibus test of differences in environmental preferences and environmental satisfaction between the items (components) for these two groups separately. In the third stage, an Importance-Performance Matrix was undertaken to explore the importance of and satisfaction with each individual environmental component as expressed by the two groups of cyclists.

4.2.3 Research Results

Considering the overall sample of respondents, males were slightly in the majority (52.7%). In terms of age groups, the 35–44 age group was the largest (37.7%), followed by 25–34 years (35.7%). Most of the respondents were from Hsinchu City and County (84.1%). A total of 43.5% were single, and 42% were married with young children. Of the 345 respondents, 125 (36%) were high-tech workers involved in the service sector for Science-based Industrial Park (HSIP) or related enterprises. The demographic results match the distribution of the population in and around Hsinchu, therefore, it can be considered a representative sample.

In terms of personal characteristics among the high-tech worker group, 62.9% were in the 25–34 age range, most lived in Hsinchu City and County (93.5%), and 56.5% were single. Among the other (non-high-tech worker) group, the largest age group was 35–44 (43.5%), 80% lived in Hsinchu City and County, and 46.9% were married with young children. In general, the high-tech workers tended to be younger and single. Except for the category of gender, significant differences were found in age, place of residence, and marital status ($p < 0.05$). Thus, the two groups demonstrated significant differences in terms of personal characteristics, thus supporting Hypothesis 1 in part.

With respect to cycling experience, the two groups did not differ significantly in cycling frequency or time spent cycling, but did differ in motivation for cycling and duration of cycling. High-tech workers cited recreation/entertainment and stress release, as well as the opportunity to make friends and expand social networks as motivating factors. Their duration of cycling was also fairly short, at around 1–3 hours per episode. The main motivations for the other (non-high-tech worker) group were the cycling itself, the opportunity to spend time with family, and getting in touch with nature. Their duration of cycling was longer than that of the high-tech workers, at 3–5 hours per episode. In summary, two of the four cycling experience variables were significantly different between groups, thus Hypothesis 1 was partially supported.

In terms of cycling resources, significant differences were found in terms of transportation resources (i.e., how they got to the site that day) and the type of bike. High-tech workers were most likely to use their own cars rather than tour buses to get to the cycling area. High-tech workers preferred to ride tandem bikes and multi-geared mountain bikes, while the other (non-high-tech worker) group preferred three-wheel bikes and fixed-gear (single-speed) bikes. The two groups also exhibited significant differences in cycling resources. It can be seen from the data in Table 4-9 that the two groups showed noticeable differences in personal characteristics, cycling experience, and cycling resources, thus confirming Hypothesis1.

TABLE 4-9 Personal characteristics, cycling experience and cycling resources of the two groups

Characteristics, cycling experience, cycling resource		High-tech workers (n=125)	The Others (n=220)	Chi-Square test	
		%	%	X^2	*p*
Sex	Male	59.7	50.3	1.750	0.186
	Female	40.3	49.7		
Age	15-24	3.2	14.5	29.399	0.000**
	25-34	62.9	24.1		
	35-44	24.2	43.5		
	45-54	6.5	11.7		
	>55	3.2	6.2		
Place of residence	Hsinchu city	62.9	57.9	6.478	0.039*
	Hsinchu county	30.6	22.1		
	Other places	6.5	20.0		
Marital status	Single	56.5	37.9	6.310	0.043*
	Married with adult children	12.9	15.2		
	Married with young children	30.6	46.9		
Cycling motivation	First priority	Recreation, entertainment, and stress release	Cycling itself		
	Second priority	Opportunity to make friends	Spend time with family		
	Third priority	Expand social networks	Getting in touch with nature		
Cycling frequency	Every day	6.5	4.8	4.334	0.363
	Often (1-2 x/week)	9.7	11.7		
	Occasionally (1 x/1-2 mos.)	17.7	24.1		
	Rare (1 x/2-3 mos.)	25.8	32.5		
	First time	40.3	26.9		
Days for Cycling	Weekdays	0.0	2.8	2.220	0.330
	Weekends	88.7	82.8		
	No difference	11.3	14.4		
Duration of Cycling	0 – 1 hr.	25.8	8.3	30.080	0.000**
	1 – 3 hrs.	45.2	22.8		
	3 – 5 hrs.	19.4	53.8		
	>5 hrs.	9.6	15.1		
Bicycle ownership	Yes	66.1	71.7	0.648	0.421
	No	33.9	28.3		
Equipment	Yes	43.5	44.8	0.026	0.865
	No	56.5	55.2		
Mode of transport to site	Bicycle	17.7	23.5	8.321	0.040*
	Motorcycle	8.1	17.2		
	Car	74.2	55.2		
	Tour Bus	0	4.1		
Type of bike	Fixed gear bike	14.5	22.1	24.866	0.000*
	Multi-Gear bike	25.8	24.1		
	Tandem bike	41.9	14.5		
	Three-wheel bike	17.8	39.3		

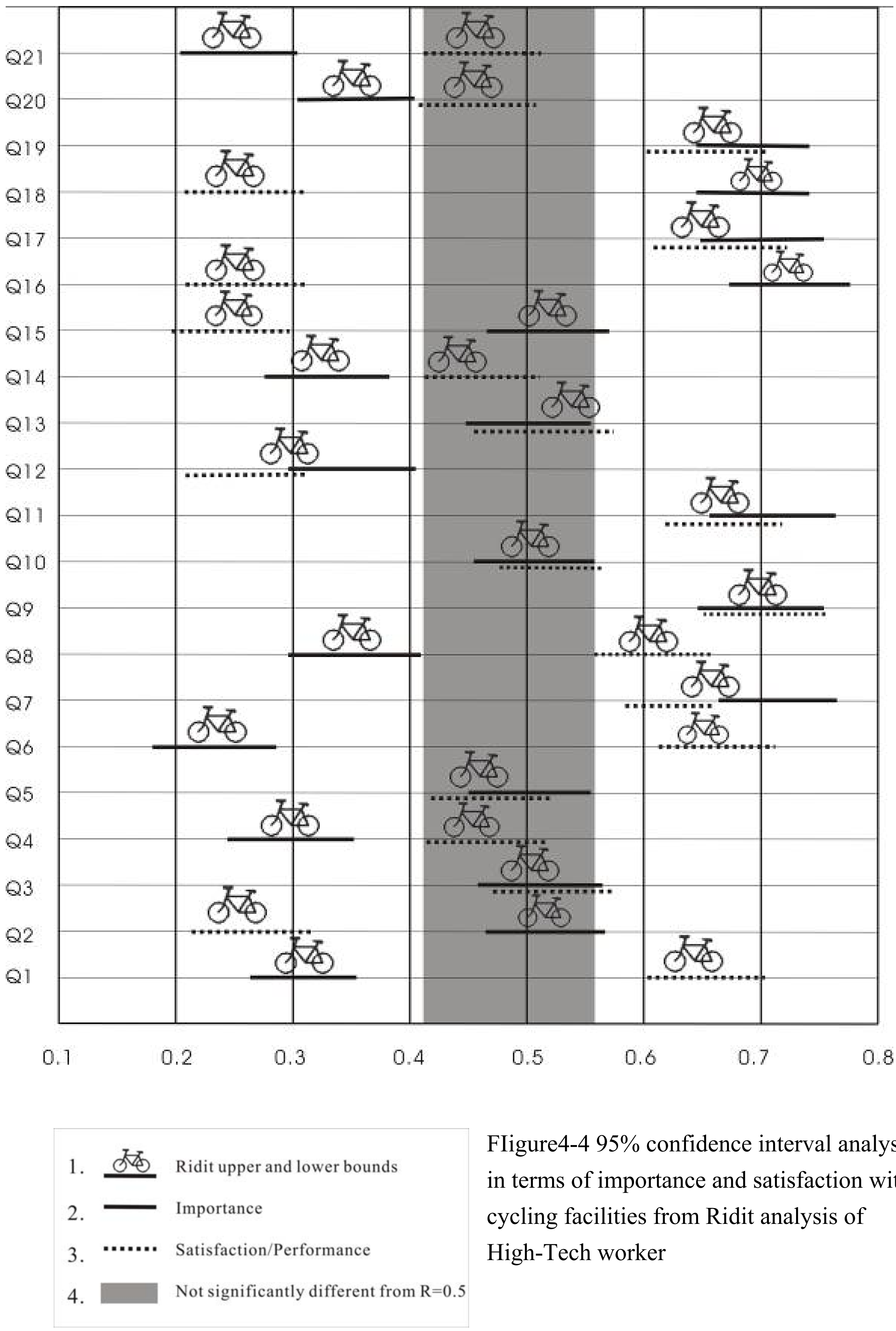
* p<0.05; **p<0.01

Moreover, differences in environmental preferences for and satisfaction with cycling facilities were analyzed for each group. The high-tech group rated seven items as being significantly important, denoted by R values greater than 0.5, and rated another eight items as being low in importance (R < 0.5). The remaining six items were not significantly different from R = 0.5 as determined by the 95% confidence interval analysis for environmental preferences. The high-tech group also revealed significant levels of satisfaction with eight items (R > 0.5), and rated another five items as being unsatisfactory (R < 0.5). Based on the 95% confidence interval analysis of satisfaction with cycling facilities from the Ridit analysis (see Figure 4-4), the balance of the items were rated as not being significantly different from R = 0.5.

The non-high-tech group indicated significant importance of nine items (R > 0.5), and rated eight other items as being of low importance (R < 0.5). The remaining four items were not significantly different from R = 0.5, based on the 95% confidence interval analysis, in terms of environmental preferences. The non-high-tech group also rated nine items as satisfactory (R > 0.5), and another seven items unsatisfactory (R < 0.5). The remaining five items were not significantly different from R = 0.5 in terms of satisfaction with cycling facilities (see Figure 4-5). Ridit values and rankings of environmental preferences and satisfaction of high-tech workers and non-high-tech workers can be seen in Table 4-10.

The value of the χ^2 distribution with 20 degrees of freedom at the significance level of α =.05 is $\chi^2(20) = 31.14$. The null hypothesis H_0 is rejected for both the high-tech workers and the other (non-high-tech worker) group. This finding demonstrates that the two groups of recreational cyclists differ significantly with respect to their importance and satisfaction ratings of the 21 environmental components, thus confirming Hypothesis 2.

Finally, an importance-performance matrix analysis of the environmental preferences for and satisfaction with cycling facilities was conducted. The vertical and horizontal axes were used to plot the importance and the performance scores, respectively. The respondents' environmental preferences (level of importance) were compared to their levels of satisfaction (performance) within each group. The government funds allocation for recreational cycling in the Hsinchu technopolis was assessed by dividing the matrix into four quadrants where the X and Y axes represent the Ridit values of the satisfaction and preferences ratings. (Figure 4-6)



FIigure4-4 95% confidence interval analysis in terms of importance and satisfaction with cycling facilities from Ridit analysis of High-Tech worker

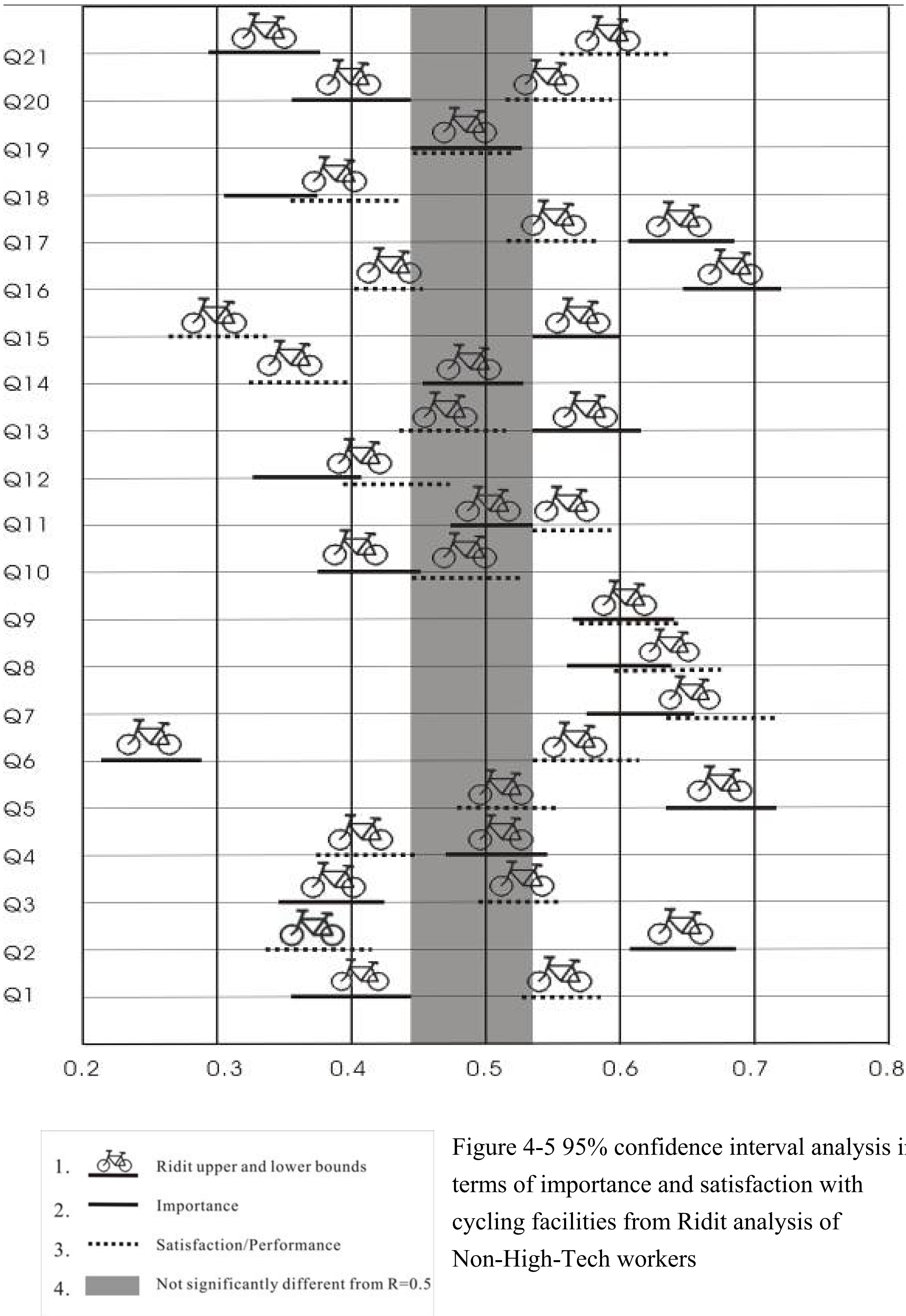


Figure 4-5 95% confidence interval analysis in terms of importance and satisfaction with cycling facilities from Ridit analysis of Non-High-Tech workers

TABLE 4-10 Cycling environmental preferences and satisfaction of high-tech workers and non- high-tech workers

Environmental components	High-Tech workers				Non- High-Tech workers			
	Importance		Satisfaction		Importance		Satisfaction	
	Ridit value	Rank	Ridit value	Rank	Ridit value	Rank	Ridit value	Rank
1.Bike route long enough, complete and continuous	0.313**	18	0.658*	5	0.406**	15	0.550*	7
2.Bike path wide enough for safety and comfort	0.516	9	0.281**	17	0.647*	3	0.377**	19
3.Gentle slopes and curve / ease of ride	0.511	10	0.523	9	0.384**	17	0.536	10
4.Rough slopes, path offering variety and challenge	0.298**	19	0.481	13	0.509	11	0.411**	17
5.Pavement quality (smooth, without bumps/holes)	0.502	13	0.488	12	0.677*	2	0.519	11
6.Pavement colorful and of diverse materials	0.233**	21	0.673*	4	0.250**	21	0.574*	5
7.Good weather	0.714*	2	0.626*	7	0.625*	5	0.676*	1
8.Area of outstanding natural beauty (AONB)	0.348**	16	0.615*	8	0.599*	7	0.637*	2
9.Bike trail passes beautiful/ famous attractions	0.699*	5	0.703*	1	0.601*	6	0.609*	3
10.Rest places and view points	0.507	11	0.518	10	0.412**	14	0.485	12
11.Parking area for cars and bicycles	0.709*	3	0.687*	2	0.511	10	0.548*	8
12.Greenery / shade trees	0.349**	15	0.271**	18	0.368**	18	0.432**	16
13.Signage system and map	0.501	12	0.503	11	0.575*	8	0.472	14
14.Tourist interpretation system	0.330**	17	0.475	14	0.495	12	0.360**	20
15.Restrooms and shower facilities	0.518	8	0.245**	21	0.551*	9	0.300**	21
16.Bike path (right of way separate from roads)	0.724*	1	0.270**	19	0.681*	1	0.443**	15
17.Reasonably priced bike rental system	0.701*	4	0.681*	3	0.647*	4	0.545*	9
18.Cafe, restaurant, and convenience store	0.696*	6	0.268**	20	0.344**	19	0.392**	18
19.Cleanliness and environment management	0.696*	7	0.657*	6	0.483	13	0.481	13
20.Accessibility	0.355**	14	0.467	16	0.402**	16	0.552*	6
21.Government efforts and promotion	0.253**	20	0.472	15	0.334**	20	0.595*	4
W statistic	442.202***		358.941***		851.347***		503.889***	

* Significantly greater than R=0.5 at $\alpha = 0.05$ ** Significantly less than R=0.5 at $\alpha = 0.05$

*** Significantly different among environmental components at $\alpha = 0.05$, χ^2 (20)=31.14

0.5 not significantly different from R=0.5 at $\alpha = 0.05$

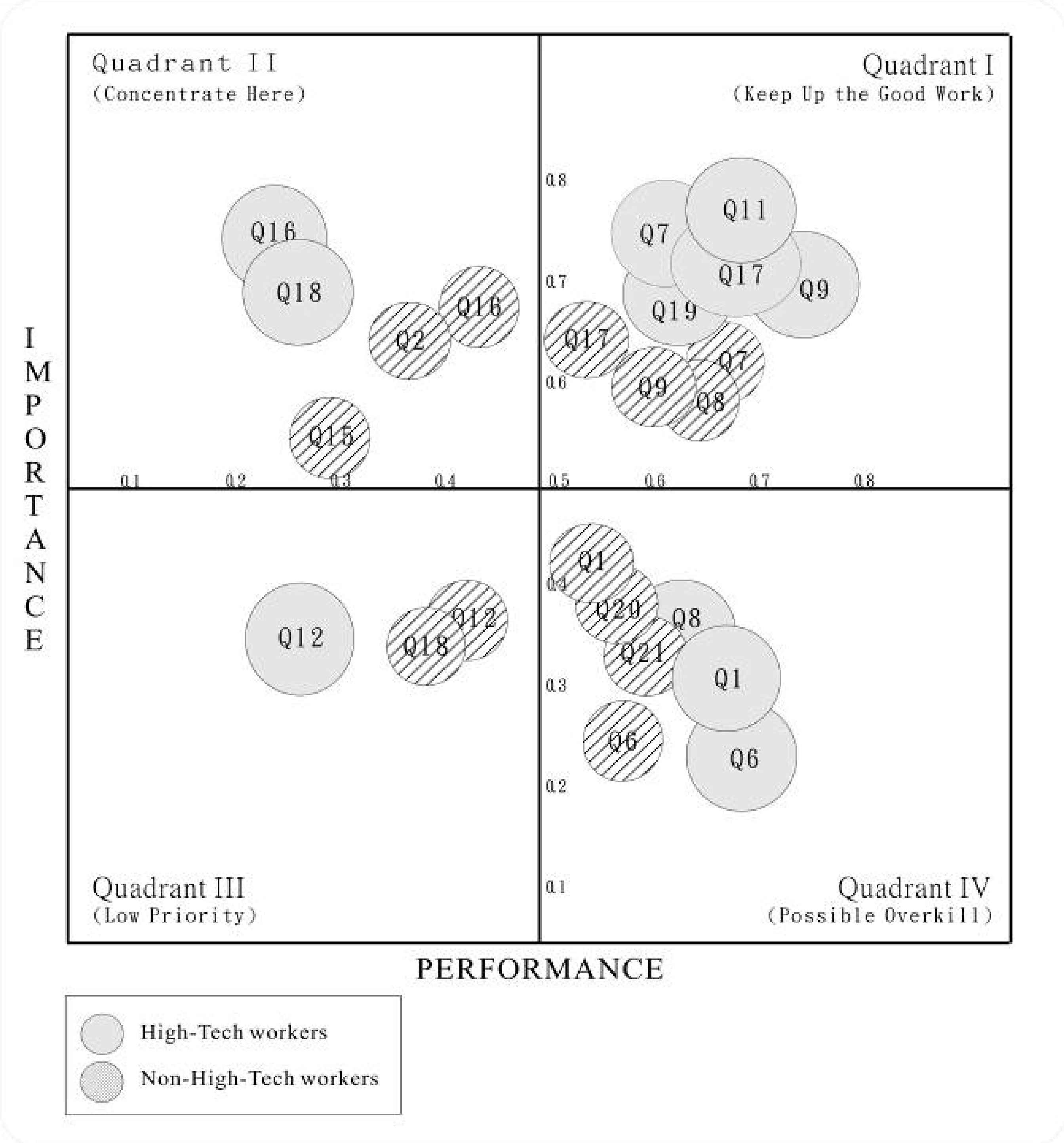


Figure 4-6 Matrix of cyclist preference and satisfaction with cycling facilities (Revised from O'Sullivan, 1991)

4.2.4 Research Findings

This section is divided into two parts: first, the importance and satisfaction of environmental components rated by two groups are compared; second, the matrix of cyclist preferences for and satisfaction with cycling facilities is discussed based on the results of the importance- performance analysis. This section also discusses the implications of our findings for allocation of government investment in bike lanes.

1. Comparison and contrast between high-tech and non-high-tech workers

(1) Environmental components considered most and least important by both groups

Both groups consider four of the environmental components to be very important, thus cycling facilities should be given priority consideration in recreational cycling planning or promotion. They included Q7 (Good weather), Q9 (Bike trail passes beautiful/famous attractions), Q16 (Bike path right of way separate from road), and Q17 (Reasonably-priced bike rental).

All levels of government need to address these components. Among these, Q16 (Bike path right of way separate from road) was rated most important by both groups, demonstrating that government planning efforts should give this first priority. Of the USD 15 million spent on the Hsinchu bike lane, about 51.67% (USD 7.75 million) was spent on linking routes to produce a continuous bike path, showing the substantial effort spent on this factor. Such investments should be employed to give priority to bike lane safety and restrict access by motor vehicles to better satisfy and safeguard users.

Five environmental components were rated by both groups as being unimportant. They were Q1 (Bike route long enough), Q6 (Pavement colorful and of diverse material), Q12 (Greenery/shade trees), Q20 (Accessibility) and Q21 (Promotion by government).

These components do not need to be given priority consideration by governmental planners. The component rated lowest in importance by both groups was Q6 (Pavement colorful and diverse). In our previous study (Chang & Chang, 2005) we found that riders preferred a simple blacktop surface, stating that ease of cycling was more important than diverse types of surfaces with various patterns or colors. Since 7.4% (USD 1.11 million) of the project money was spent on this feature, future planners would be well-advised to reconsider the necessity of heavy spending to diversify the path surface.

(2) Components considered important by one group but not by the other

The environmental component rated as important by the high-tech worker group, but not by the non-high-tech worker group (i.e., Q18 (Cafes, restaurants, and convenience stores)) serves as a reference for private developers and businesses. Fulfilling the requirements of high-tech workers can attract them to the cycling facilities, thereby increasing the number of riders and overall use of the cycling site, as high-tech workers, on average, spend more than do non-high-tech workers. Private business should be encouraged in the future to step in and satisfy these needs to attract more high-tech workers to the cycling facilities.

Environmental components rated significantly more important by the other (non-high-tech worker) group (i.e., Q8 (Areas of outstanding natural beauty)) can provide a valuable reference for government agencies planning recreational cycling facilities for future development strategies to fulfill the requirements of most local residents.

These components can serve as guidelines for development strategies aimed at typical non-high-tech workers who tend to earn and spend less than high-tech workers, but who constitute most of the population. The non-high-tech workers strongly emphasize contact with nature (Q8, AONB). Spending in that area to date has been almost 0.2% (around USD 30,000) of the project. Environmental protection, environmental education, and appropriate environmental management should be given increased emphasis in the future.

2. The importance-performance matrix of cyclists' preference for and satisfaction with cycling facilities

The right upper quadrant (Quadrant 1) of Figure 3 displays components of high preference and high satisfaction for both groups. The left upper quadrant (Quadrant 2) displays components of high preference but low satisfaction for both groups. The left lower quadrant (Quadrant 3) shows components rated as unimportant, which were also rated as unsatisfactory. The right lower quadrant (Quadrant 4) shows components rated as not necessarily important but with which respondents were satisfied.

(1) High importance and high satisfaction components

The upper right quadrant, known as the “keep up the good work” area (O'Sullivan, 1991), shows important cycling facilities in which the government is performing well and continuous efforts in this direction are desirable.

The components of high preference and high satisfaction of both groups are recognized as the strengths of the Coastal Bike Lane project: Q7 (Good weather), Q9 (Bike trail passes beautiful/famous attractions), and Q17 (Reasonably-priced bike rental). Government efforts in the first two areas have so far been successful, but must be continued in order to encourage cycling. Efforts related to Q17 will be discussed in more detail below.

Among the three components rated by both groups as important and satisfactory, Q7 (Good weather and climate) confirms the findings of Ritchie (1998) and Gardner (1998) that recreational cyclists are fair-weather cyclists. Because the technopolis of Hsinchu is in the tropics, the summer can be oppressively hot, causing many locals to avoid cycling. Conversely, European and American tourists may find the heat a welcome change to their colder climates.

The government has made strong efforts along the coastline to make it beautiful, famous, and interesting, and 15% (USD 2.25 million) of the budget was spent on Q9 (Bike trail passes beautiful/famous attractions). This component contributes to recreational cycling development and is considered important by cyclists. Another such component is Q17 (Reasonably-priced bike rental); however, that is related to investment by the private sector in coastal areas rather than government. This does not alter the fact that respondents considered it an important factor related to cycling, thus the government should encourage continued efforts by private enterprise in this area.

Q11 (Parking area for cars and bicycles) and Q19 (Cleanliness and environmental management), rated by the high-tech workers as both important and satisfactory, show where the government has done well. Apparently, the government invested 0.74% (around USD 110,000) of the project budget on parking facilities, and 1.5% (around USD 225,000) on cleanliness and management, and those efforts were noted and appreciated by the respondents.

Q8 (AONB) was rated by the non-high-tech worker group as important and satisfactory. As the natural environment of Hsinchu’s coastline is a precious resource, government planners do not need to invest significantly in facilities, but can focus on preserving the natural environment.

(2) High importance and low satisfaction components

The upper left quadrant, known as the “concentrate here” area (O'Sullivan, 1991), consists of factors of high importance and low satisfaction; areas where government agencies have not yet satisfied cyclists’ requirements. These components, recognized as the weaknesses of the Coastal Bike Lane project, have not been properly handled and are in need of serious improvement. With regards to the component most in need of improvement and funding, Q16 (Bike path right of way separate from roads) was reported by both groups as being the most important component, but one with which they were strongly dissatisfied. If this problem cannot be rectified, the entire USD 15 million of investment will be in jeopardy.

Q18 (Cafe, restaurant, and convenience store) was rated by the high-tech group as very important but they also expressed strong dissatisfaction. The government should draft a plan to encourage private investment in this area, which would attract more high-tech cyclists while introducing business opportunities to the local economy.

Q2 (Bike path wide enough) and Q15 (Restroom and shower facilities) were rated by the non-high-tech worker group as important but they also expressed dissatisfaction. In particular, Q15 was the component ranked by both groups as the most unsatisfactory, thus reflecting the current severe lack of restroom and shower facilities. Spending on restrooms was 0.96% (USD 144,000) of the project budget, a figure that should be increased in order to satisfy all users.

(3) Low importance and low satisfaction components

The lower-left quadrant, known as the “low priority” area (O'Sullivan, 1991), reflects components where minor efforts are being exerted but also ones that do not require attention. Cyclists were not satisfied, but also did not consider these factors important.

Q12 (Greenery/shade trees), which was rated by both groups as having low importance and low satisfaction, suggests that government efforts on planting was not adequate. The government spent 9.46% (USD 1.42 million) of its budget on planting shade trees, revealing the importance placed on creating a green environment, yet cyclists still reported dissatisfaction. This component requires not only improvement but also promotion. At least one factor may explain why respondents did not consider Q12 (greenery and shade trees) to be important. The data was collected in the late afternoon in spring, a time when cyclists did not face intense summer heat and were able to benefit from the steady, comfortable breeze typical of coastlines.

Q18 (Cafe, restaurant, and convenience store) was rated by the non-high-tech worker group as unimportant and dissatisfactory. In terms of the importance of Q18, the two groups differed. The other (non-high-tech worker) group rated Q18 as unimportant, while the high-tech group rated Q18 as being quite important, but they were also unsatisfied (i.e., Quadrant 2).

(4) Low importance and high satisfaction components

The lower right quadrant, known as the “overkill” area (O'Sullivan, 1991), shows major efforts that are being performed very well by the government but do not require further efforts.

Q1 (Bike route long enough) and Q6 (Pavement colorful and diverse), rated by both groups as having low important and high satisfaction, are recognized as being adequately handled by government.

These components indicate areas where facilities are already adequate and do not immediately require further investment. On Q6 (Pavement colorful and diverse) 7.4% (USD 1.11 million) of the budget was spent in an apparent case of over-design, as the government frequently overspends on landscape facilities.

Q8 (AONB) was rated by the high-tech group as unimportant but satisfactory. Again, the two groups differed in terms of importance on Q8. The high-tech group rated Q8 as unimportant, while the other (non-high-tech worker) group rated Q8 as important, but both rated it as being satisfactory.

Q20 (Accessibility) and Q21 (Government efforts and promotion) were rated by the non-high-tech worker group as not important but satisfactory. These components have been adequately handled by the government, and do not need further investment at this time.

4.3 The Obstacles of Students Cycling to School

4.3.1 Problems and Hypotheses

With an increasing awareness that global warming and its related climate change are factors affecting life and health, the Hsinchu Technopolis urgently needs to review its current systems of transportation and patterns of behavior of its citizens in order to provide a more habitable and sustainable environment. Our research has revealed that students in the Hsinchu area depend heavily on their parents to get to school using both motorcycles and cars. Specific data are as follows:

1. 47% of junior high school students (ranging age from 13 to 15) get to school by car or motorcycle in the city, and 53% in the county.
2. It is also revealing that 94% of students in the city and county can cycle, and most of them own bicycles (79%); however, only 15% of them ride their bikes to school.

4.3.2 Data Collection

In December 2006, as a first step in the study, the authors administered the PBIC checklist to students in 22 schools in the Hsinchu Technopolis area, which yielded the following result: the average score of bikeability was 14.64, which means "conditions are poor". This reflects a situation in which the cycling environment is not at all friendly for students to get to school in the Technopolis by riding their bikes.

Afterwards, in order to get objective data, a survey was conducted to collect student and parent information and a descriptive analysis was applied to examine their characteristics by using the Rasch model as a basis for analyzing the data. Random sampling led to the choice of two junior high schools; one located in the city of Hsinchu, which represents the urban location, and the second one located in Hsinchu County, which represents the suburban location. A total of 687 valid questionnaires were collected in the school located in the city and 923 in the one located in the county.

Later the data was organized to represent three categories of variables in order to determine cycling difficulties and the abilities of the students with ages ranging from 13 to 15 years old:

1. Student personal characteristics (which include gender and age (grade))
2. Family characteristics and the parents' thoughts and attitudes about letting their children ride bikes to school
3. Location of schools (city or county)

Three hypotheses were proposed to explain the differences and relationships among these variables:

1. Students' cycling abilities are different between male and female.
2. Students with higher levels of cycling ability will be in higher grade than students with lower levels of cycling ability.
3. Students with higher levels of cycling ability will have greater parental support for cycling to school than students with lower levels of cycling ability.
4. Students with higher levels of cycling ability will have higher educated parents than students with lower levels of cycling ability.
5. Students' cycling abilities are different between living in urban area and suburban area.
6. Students' perceptions of cycling to school are affected by traffic conditions (which include narrow shoulders, crossing intersections, left turns, uneven paving, shared roads, trucks, heavy traffic, and shoulders occupied).
7. Students' perceptions of cycling to school are affected by physical conditions (which include darkness, rain, and wind).

Graphically the research structure can be systemically conceptualized as shown in figure 4-7. For this research two junior high schools in the Hsinchu Technopolis area of Taiwan were chosen at random for administering the questionnaire.

Hsinchu County has a population of around 920,000 with 530,000 living outside the city and 390,000 within the city of Hsinchu. The population ratio is 1.35 to 1 and the sampling of students is almost the same as the population ratio; 923 from Hsinchu County and 687 from the city of Hsinchu. The sample matches the distribution of the population and, therefore, can be considered as representative.

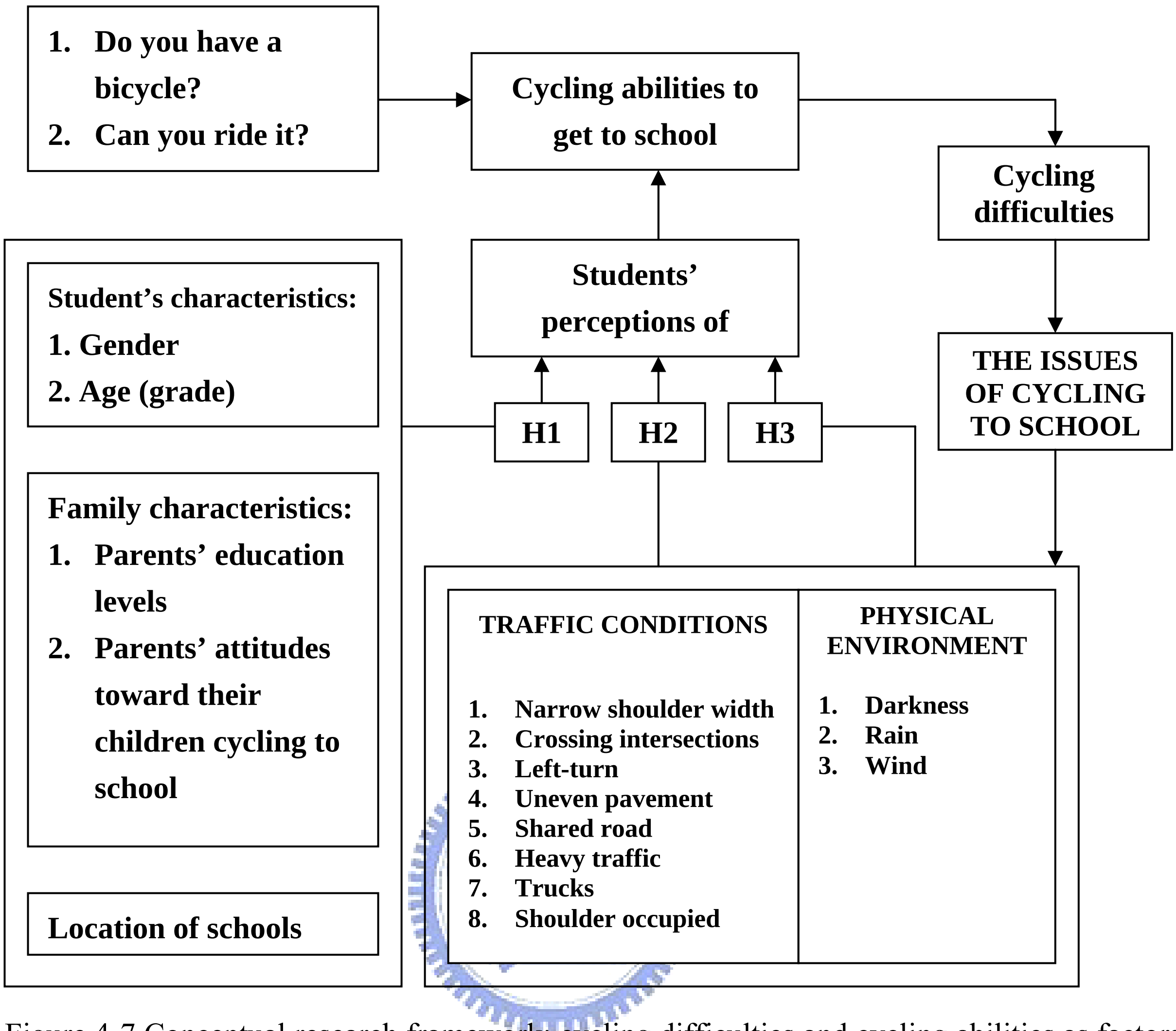


Figure 4-7 Conceptual research framework: cycling difficulties and cycling abilities as factors influencing students' cycling to school.

Questionnaires were administered in spring 2007 and 1,610 valid responses were obtained. Afterwards the research process was divided into three tasks:

1. Descriptive analysis of students' profiles

2. The Rasch analysis

3. Cycling difficulties and cycling abilities analysis

As regards Hypothesis 1 (as represented in Figure 4-7) the variables and data obtained are organized and represented in Table 4-11. The results of descriptive analysis of the Students' profiles are shown as follows:

1. Regarding the variable "gender," girls were slightly in the majority (53%) of the overall sample of students.

2. In terms of "grade and age," the second grade group (14 year-olds) was the largest (35%), followed by the first grade group (13 year-olds; 33%), and third grade group (15 year-olds; 32%).

3. In regard to the family characteristic variable "parents' education," 72.1% are at or above the college level, both in the city and the county. This is not an unexpected finding since the research area is a science-based Technopolis, and the average education is higher than is found in other areas.

4. With regard to "Parents' attitudes of children cycling to school," 27.4% of the parents supported the idea, and 16.0% parents were opposed to it. The vast majority (61.4%) did not have an opinion one way or the other.

Table 4-11 Personal and family characteristics of respondents

Variables		**City Students**		**County students**		**Total**	
Gender	Male	292	42.5%	465	50.4%	757	47.0%
	Female	395	57.5%	458	49.6%	853	53.0%
	Total	687	100.0%	923	100.0%	1610	100.0%
Age	13 years old	210	30.6%	323	35.0%	533	33.0%
	14 years old	240	34.9%	320	34.6%	560	35.0%
	15 years old	237	34.5%	280	30.4%	518	32.0%
	Total	687	100.0%	923	100.0%	1610	100.0%
Parents' Education	Primary	34	4.9%	40	4.3%	74	4.6%
	High school	145	21.1%	230	25.0%	375	23.5%
	College	386	56.2%	491	53.2%	877	54.5%
	University	105	15.3%	130	14.1%	235	14.6%
	Graduate school	17	2.5%	32	3.4%	49	3.0%
	Total	687	100.0%	923	100.0%	1610	100.0%
Parents' Attitudes towards cycling to school	Disagree	110	16.0%	148	16.0%	258	16.0%
	No opinion	422	61.4%	489	53.0%	911	56.6%
	Agree	155	22.6%	286	31.0%	441	27.4%
	Total	687	100%	923	100%	1610	100%

This research applied the Rasch model to analyze the cycling abilities of students from two schools in the Technopolis. The mean item difficulty was set at 0, and the mean measure of student ability was set at -0.15 logit. This means that the item content (i.e., the situation to which the item referred) was considered to be slightly more difficult for the students.

In the Rasch model, reliability is estimated for both students and items. When the reliability index is larger than 0.80, it means that the scale (student or item) is reliable. Table 4-12 shows that student reliability (0.87) is greater than 0.80, which falls within the reliable range. Item reliability (0.99) is far greater than 0.80, which means that the results are very reliable. Thus, this questionnaire and the results obtained are useful in measuring the cycling difficulties of school students for the Hsinchu case.

Table 4-12 Reliability of the Rasch model applied in the Hsinchu case

STUDENTS		*1,610 INPUT*		*1,610 MEASURED*		
	Raw score	Count	Ability	Error	Infit Zstd	Outfit Zstd
Mean	23.1	8.0	-0.15	0.55	-0.2	-0.2
RMSE : 0.57				*Person Reliability : 0.87*		
ITEMS		*8 INPUT*		*8 MEASURED*		
	Raw score	Count	Difficulty	Error	Infit Zstd	Outfit Zstd
Mean	4518.7	1562	0.00	0.03	-0.2	0.3
RMSE : 0.03					*Item Reliability : 0.99*	

4.3.3 Cycling Difficulties and Students' Abilities

As derived from the WINSTEPS output, eight of the eleven items have been ranked according to their level of difficulty (Bi) as can be seen in Table 4-13. Three of the eleven items were dropped from the analysis because no significant between-group differences were found for those items.

Those eight items' infit Zstds and outfit Zstds fall within ±2.00 standard deviations from the mean, which means those items are reliable. The higher the item's difficulty measure, the more difficult that task was perceived to be by the students. The respective item difficulty ranges are: +0.35 ~ -0.73 logits.

The results have shown that:

1. Students cycling to school perceive the most difficult conditions as being the presence of trucks, heavy traffic, rainy and windy conditions.

2. In contrast, darkness, cars occupying the shoulder, making left turns and crossing intersections are thought to be of low difficulty and easy to overcome.

3. Narrow shoulder width, uneven pavement, and cycling on shared roads are not rated as being of significant difficulty by students.

Table 4-13 Results of items ranking according to raw score and difficulties

ITEM	Raw Score	Diffi-culty	Infit Zstd	Outfit Zstd
• Can you safely ride your bike when there are trucks on the road?	4198	0.35	-2.0	-1.7
• Can you safely ride your bike when there is heavy traffic on the road?	4225	0.34	-1.0	-0.2
• Can you safely ride your bike when it is raining?	4454	0.08	-1.7	-1.9
• Can you safely ride your bike when it is very windy?	4473	0.08	-1.2	-1.0
• Can you safely ride your bike when crossing intersections with fast-moving traffic?	4486	0.01	1.6	2.0
• Can you safely ride your bike when turning to the left?	4532	-0.05	1.5	2.0
• Can you safely ride your bike when cars occupy the shoulder?	4593	-0.08	0.8	1.3
• Can you safely ride your bike when it is dark?	5189	-0.73	0.7	1.5

The students' cycling ability is also examined in the Rasch model. This model transfers the raw score into a logit score through an odds ratio. The students' abilities by logit scores are between -4.38 and +4.12. This means that most of the students' cycling abilities are very low.

Figure 4-8 provides a scatter plot of the weighted (infit) and outlier-sensitive (outfit) fit statistics for the estimates of item measures. The infit and outfit values are expressed as *z*-scores for the normalized distribution of students (relative to the Rasch model expectations). The central rectangle shows the boundaries of the 95% confidence interval and each dot represents a student response. The X-axis reflects the outfit. Student responses falling in the upper right quadrant represent over dispersion, while student responses falling in the lower left corner reflect under dispersion (i.e., outliers). Those student responses are discarded. It should be noted that 1,277 of the 1,610 Infit Zstd and Outfit Zstd scores (79.3%) fall within ±2.00 standard deviations from the mean, thus modelling the Guttman Scale.

Further analyses examined students' cycling abilities based on a variety of student and parent characteristics. The results of these analyses can be seen in Table 4-14. "Mean Ability" reflects the mean logit for the groups under examination.

Boys' cycling abilities are significantly greater than the abilities of girls. Age also appears to have a role in cycling ability. The results indicate that 15 year-olds have significantly better cycling abilities than 14 year-olds who, in turn, are significantly better than the 13 year-olds.

Parents who support the idea of their children cycling to school have children with significantly better cycling abilities than the children of parents who do not support the idea of their children cycling to school. Finally, students who live in the city have significantly better cycling abilities than students who live in the country.

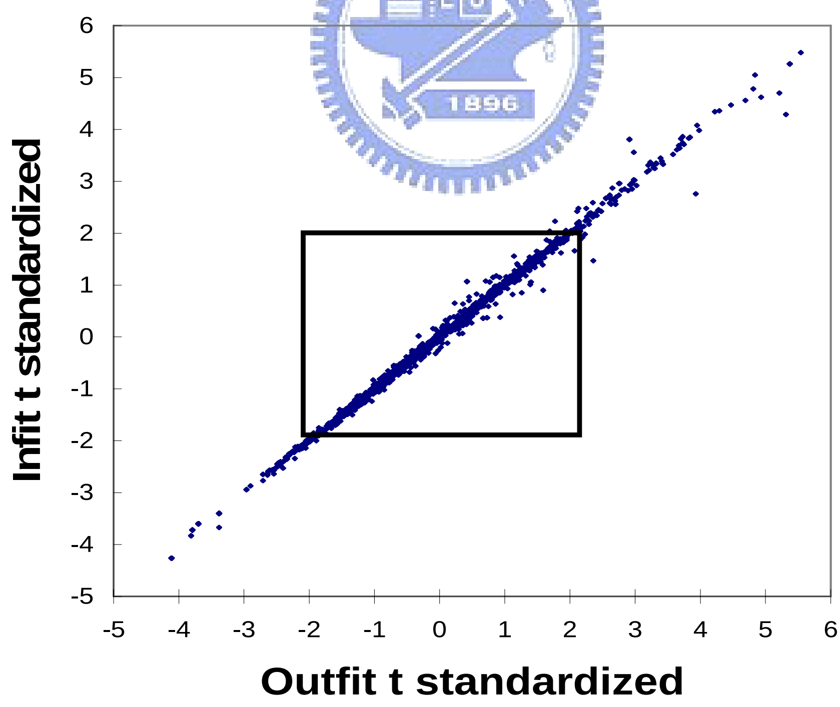


Figure 4-8 Standardized residuals of the difficulty scale items

Table 4-14 Differences in cycling abilities based on student and parent characteristics

Variable	Group	Number	Mean Ability	*P*
Gender	Boy	588	0.3078*	< .001
	Girl	689	-0.5993	
Grade (age)	Third (age 15)	401	-0.0519*	< .001
	Second (age 14)	451	-0.0559	
	First (age 13)	425	-0.4373	
Parents' Attitudes	Agree	229	0.4054*	< .001
	No opinion	707	-0.1396	
	Disagree	341	-0.6629	
Location	School in City	589	0.0437*	< .001
	School in County	688	-0.3745	

Furthermore, the author tried to estimate the individual group by *t*-test, the results are as follows:

Variable	Group	*p*- value
Grade	First grade vs. second grade	0.001
	First grade vs. third grade	0.001
	second grade vs. third grade	0.971
Parents' Attitudes	Agree vs. no opinion	0.000
	Agree vs. disagree	0.000
	No opinion vs. disagree	0.000

4.3.4 Results and Findings

In spite of the fact Taiwan is a world leader in the manufacturing of bicycles, the numbers of students who cycle to school is low. The extant literature and the current study suggest that, while students possess bicycles and only a small percentage (16.0%) of parents are opposed to the idea of their children cycling to school, there must be other reasons for students not cycling to school. Thus, the current study examined a variety of potential obstacles to cycling and the extent to which students perceived them to present difficulties while riding.

The abilities of the students to cycle are generally poor. However, it is logical to think that the old adage "practice makes perfect" might be applicable in this situation. If students do not practice riding it is perfectly reasonable to expect that they will have lower levels of ability than those who have more practice. It was also evident from the data that ability is related to age. More specifically, as a child ages he or she becomes more proficient when riding. This is a normal developmental principle; however, without opportunity to participate the skill will never be developed—in general, ability is concomitant with time spent on task.

The data in this study indicate that boys have higher levels of cycling ability than do girls; however, this is not cause and effect. As noted in the previous paragraph, skill development parallels time practicing and there is no reason to think that males have some type of innate superiority to females in the area of cycling ability. Further research would be needed for a definitive answer, but the literature on physical ability testing indicates that while males have a slight advantage in upper body strength, there is generally no significant difference found for physical agility, which is certainly more related to cycling ability.

The results of this study suggest a larger issue seems to be at the root of the lack of student cycling. More specifically, perceived obstacles within the environment in which they would be riding appear to be at the heart of students not riding bikes to school. Given eleven possible impediments to cycling (8 related to traffic conditions and 3 related to weather; see Figure 4-3-1) the three most often rated as being problematic were heavy traffic, trucks, and rain. Dealing with darkness, cars occupying the shoulder, and making left turns were rated as being less difficult obstacles.

4.4 Policy Implications and Discussions

Obviously, there is not a lot that can be done about weather conditions; however, addressing the other issues that have emerged as impediments to cycling is no different that what has been done, and is currently being done, in Europe and the United States (Aultman-Hall and Hall, 1998; Moritz, 1998). It seems logical that if the majority of students are currently using cars and motorcycles as the primary modes of transportation to school, and "heavy traffic" is one of the major impediments to cycling, there is a relationship between the two. More specifically, if more students rode their bicycles to school the volume of motor-driven traffic would decrease.

Ideally, the installation of cycling lanes would circumvent the vast majority of the issues that students perceive as leading to difficulty in cycling to school. Practically, however, this may not be possible in all areas. In lieu of the "ideal" the government could implement a "cycling awareness" campaign that would educate drivers about the presence of cyclists on shared roads and provide guidelines for driving safely in their presence. Many cities in the United States have implemented a system of school safety zones (FHWA, 2002). During the hours when students are going to, or coming home from, school flashing lights by the side of the roads inform drivers that the speed limits have been temporarily reduced to, usually, 20 MPH. Penalties for violating the speed limit are severe.

In order to deal with the issue of trucks, it might be possible to restrict their times on city streets so as to allow students to cycle to and from school when trucks are banned. This would require some new logistics on the part of the trucking companies, but it would not be impossible and all parties would soon adjust.

While the current study examined a relatively small, though important, number of impediments to cycling, there are a variety of other potential obstacles that should be examined. For example, citizens' perceptions of sharing roads with increasing numbers of bicyclists, police willingness to enforce more stringent traffic laws, and the impact of decreasing traffic flows at peak cycling hours. More unusual, though nonetheless real, issues of providing cycling classes, mandating practical cycling tests, and the use of safety equipment (e.g., helmets) will also need to be examined.

All of the issues raised by this study that are obstacles to cycling that prevent students from riding their bicycles to their schools should become a priority targets for the Taiwanese government in order to encourage and expand cycling opportunities.

CHAPTER 5 CONCLUSIONS AND RECOMMENDATIONS

Many governments envision establishing a Technopolis and devote considerable resources towards creating an environment that provides a good quality of life to attract high-tech workers. Following this objective this study contributes to understand the cyclists' environmental preferences in different compared levels: bicycle tourists in national scenic bikeway with recreational cyclists in Hsinchu Technopolis' bike lane and high-tech workers with the local non-high-tech worker population in Hsinchu Technopolis.

To get further understanding to the topic, user's environmental preferences is broaden with a new dimension: cycling difficulties. Taking as reference the cycling difficulties faced by Hsinchu Technopolis students getting their schools, this study offers also new empirical areas needing of future research.

Also, the study was used to investigate government investment in this area in order to provide environmental planners with a reference for attracting high-tech workers. City governments should invest in and promote a recreational cycling environment as one factor to ensure a "good quality of life" for high-tech workers.

This research investigated environmental preferences for, and satisfactions with, cycling facilities for recreational cyclists in a technopolis in Taiwan. The author conducted an in-depth examination of the different demands of recreational cyclists and conducted statistical tests to detect significant differences in those preferences for and satisfaction with various environmental cycling components between two groups of workers.

Importance-Performance Analysis enables environmental planners to identify important environmental factors while simultaneously assessing the cycling facilities' performance in terms of satisfaction with those factors. The placement of components on the four-quadrant allows the government to readily make decisions regarding resource allocations, since the placement of each component reflects a specific potential strategy for the government. The conclusions allow the government to identify the environmental factors important to cyclists and assess the perceived quality of existing facilities. The analysis produced valuable information for evaluating the efficiency of government resource allocation in constructing cycling facilities.

The results examined the efficiency of government resource allocation and provided suggestions for a reasonable cycling policy for recreational cycling facilities in general, and for technopolises in particular.

As for students, cycling to school provides them with opportunities to have meaningful social interactions and provide physical benefits while protecting the environment at the same time. It is, therefore, socially correct for the government of Taiwan to promote this alternative mode of transportation as a relevant part of our life and lifestyle today.

The results of this study suggest that, with a large population and numerous automobiles, the government of Taiwan needs to consider urgently in the short run how to encourage increasing use of bicycles to ensure that children can safely cycle to school. Therefore, the government must decide how best to use the land in order to improve the state of the roads and street networks (based on the pedestrians' and cyclists' needs) along with a package of regulations (as discussed earlier) to provide a smooth and safe cycling experience and a healthy high-quality standard of life for all Taiwanese citizens.

5.1 Planning and Policy Implications

5.1.1 New strategies for bicycle promotion in Taiwan

Finally, some new strategies to promote bicycle activities in Taiwan are provided from planning implication point of view. To stimulate the usage of bicycles, innovative promotion strategies are needed. Towards that end, three promotion examples are provided and more ideas are inspired to encourage the activities of bicycle in the future.

1. First Bicycle Industrial Park in Taiwan

There is a "Bicycle Industrial Park Scheme" initiated in Chunghwa County by the local government and bicycle industries. The aim of the park is to build a "bicycle mall" to promote bicycle related products and also to encourage more cycling tourists to visit the county.

2. Cycling the Island

"Cycling the whole island" becomes a fancy target among the citizens of Taiwan. From 7 years old to 70 years old, many people have a dream to cycling the Island within one week.

It is also a challenge for the youth to cycle different distances when they grow up. The newly-elected president Ma expects that 16 year-olds can cycle at least 100kms; 18 year-olds can cycle at least 200kms; and 20 year-olds can cycle the whole Island.

3. North cycle routes from Keelung to Hsinchu Technopolis

The central government tries to connect the cycling routes from county to county. The government initiated two cycling routes in the north part of Taiwan (from Keelung to Hsinchu Technopolis). One is a coastal cycling route; the other is mountain cycling route.

5.1.2 Applying the Importance and Performance Analysis for governments resources allocation

By applying the importance-performance matrix analysis, the cyclists' environmental preferences for and satisfaction with cycling facilities can be conducted. The cyclists' environmental preferences (level of importance) can be compared to their levels of satisfaction (performance), therefore the government funds allocation for recreational cycling facilities can be assessed by dividing the matrix into four quadrants.

The right upper quadrant (Quadrant 1) displays components of high preference and high satisfaction. The left upper quadrant (Quadrant 2) displays components of high preference but low satisfaction. The left lower quadrant (Quadrant 3) shows components rated as unimportant, which were also rated as unsatisfactory. The right lower quadrant (Quadrant 4) shows components rated as not necessarily important but with which respondents were satisfied.

1. High importance and high satisfaction components

The upper right quadrant, known as the "keep up the good work" area (O'Sullivan, 1991), shows important cycling facilities in which the government is performing well and should continuous make efforts in this direction.

2. High importance and low satisfaction components

The upper left quadrant, known as the "concentrate here" area (O'Sullivan, 1991), consists of factors of high importance and low satisfaction; areas where government agencies have not yet satisfied cyclists' requirements. These components, recognized as the weaknesses, have not been properly handled by the government and are in need of serious improvement.

3. Low importance and low satisfaction components

The lower-left quadrant, known as the “low priority” area (O'Sullivan, 1991), reflects components where minor efforts are being exerted but also ones that do not require attention. Cyclists were not satisfied, but also did not consider these factors important. Therefore, the governments do not necessary put them in priority.

4. Low importance and high satisfaction components

The lower right quadrant, known as the “overkill” area (O'Sullivan, 1991), shows major efforts that are being performed very well by the government but do not require further efforts. Governments have adequately handled.

5.2 Recommendations

The author applied the Ridit analysis and Rasch analysis to measure the cyclists’ preference and difficulties in a Technopolis. The author suggests that in the future, the survival model can be applied to investigate more information about the cyclists.

When considering the experience of people using bicycle, the life-table method is useful in examining the probability of cycling experience at different age intervals according to the numbers of sampled cyclists who had experienced bicycle riding and their ages at initial experience. Specifically, this approach enables us to estimate the conditional probability of cyclists experiencing riding within different age groups and the survival probability (i.e., the term “survival” in this study means people have no cycling experience) for cyclists who had not ridden a bicycle beyond a specific age.

The observation of the initial cycling age in the future study will be a time-to-event process with two possible outcomes: an event observation or a censored observation. An event observation indicates the initial age of a sampled cyclist engaging in cycling. A censored observation, however, represents a sampled cyclist who has not yet to experience cycling; his/her age at the time of the survey is the censored time. As the age of cycling debut is retrospective data obtained through recall, the stated age may be an approximation of the real value (Yeh etc, 2008).

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