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碩 士 學 位 論 文

騎單車是為了休閒還是實用：
單車休閒與單車通勤的關係

RIDING FOR LEISURE OR RIDING FOR FUNCTION: THE RELATIONSHIP BETWEEN RECREATIONAL BICYCLING AND BICYCLE COMMUTING

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ABSTRACT OF THE THESIS

Riding for Leisure or Riding for Function: The Relationship between Recreational Bicycling and Bicycle Commuting

In some places, bicycles are considered as one of the transport tools, and riding there is for function, while in some other places, bicycles are taken as physical activity, and thus riding there is for leisure. Riding for leisure or for function? 450 recreational cyclists from bicycle clubs and bicycles activities were sampled using convenience sampling, and there were 392 valid questionnaires or 89.2% of the sample. A self-developed questionnaire was administered to the respondents. This research firstly dealt with the relationship between recreational bicycling and bicycle commuting, second, the motivations and constraints of bicycle commuting were investigated, and finally, bicycle commuting policy was proposed. After the descriptive statistics analysis and Chi-square test, I concluded that there were strong connections between recreational bicycling and bicycle commuting, 38.5% of recreational cyclists also choose bicycle commuting. The motivations for bicycle commuting were enjoying riding bicycle, improving fitness, saving fuel, being environmentally-friendly, controlling weight, and commuting distance was short. The constraints to bicycle commuting were climate, lack of bikeways, bicycle theft, poor air quality, bad pavement, and safety. It is possible to encourage more cyclists to commute with bicycles by cycling awareness programs and better bicycling policies. The Taiwanese government should utilize the advantages of bicycle commuting, and promote cycling in Taiwan, not just for recreational purposes, but also for bicycle commuting purposes.

Key words: bicycle commuting, bikeway, cyclist

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Chapter 1

INTRODUCTION

Background and Motivation

People faced a transportation revolution in the twentieth century, with motorized vehicles propelling us into a more comfortable and faster transportation era. Motorized transportations are taken as a symbol of developed-machines. In 1950, there were about 53 million cars on the world's roads; only four decades later, the global automobile fleet became over 430 million, more than an eightfold increase (Walsh, 1992). However, Australian health authorities now recognize our sedentary lifestyle and our reliance on motorized travel as a major ongoing health issue (Sallis, Bauman & Prat, 1998), and the environmental impact and sustainability issues are also of concern (Hsieh, 2002).

The decline in levels of physical activity in most developed countries has been accompanied by a growing reliance on the car for transport in urban areas (Mason, 2000; Lumsdon & Mitchell, 1999). In the last 50 years, there has been an increase in the number and length of car trips while the proportion of trips made by physically active modes of transport, such as walking and cycling, has decreased (Ling, Kwang & Tjhin, 2002).

Bicycling, the green mode is an ideal way of traveling from the point of view of energy conservation, environmental friendliness and social equality (Tolley, 1990). Russell (1982) claimed that bicycling is a lifelong sport. The bicycle is acknowledged for its cost effectiveness and efficiency over short distances in urban areas (Ho, 2005). Wu and Zhang (2004) and Ho (2003) stated that the bicycle was once the main transport mode in Taiwan, but bicycle usage was gradually decreased because of the widespread of motorcycles and automobiles. However, the bicycle revival was stimulated by the global oil crisis in the early

1970s (Chang & Chang, 2003).

Taiwan is known as the kingdom of bicycles (Liao, 1998; Zhu, 2001); however, it has never been a kingdom of cyclists (H. W. Chang, 2004). In Taiwan, most of the bicycles are for export, 95% of the bicycles are for export use, Taiwanese purchases only five percent of bicycle produced in Taiwan (Liao, 1998), and the American market accounted for 30% of bicycle exports (Ou, 1998). On the average, only five out of 100 Taiwanese own a bicycle. In the Netherlands, the average person owns 1.6 bicycles.

Due to these factors, bicycling is an emerging trend as an important leisure and transportation mode. Yang and Chang (2005) stated that bicycle usage has increased in recent years as people become more aware of its health benefits and environmental protection. According to the Department of Transportation of Taipei City Government (2004), bicycling is the most efficient transport mode in getting to a destination within a five km radius if inside a city like Taipei.

Still, bicycling in Taiwan is not prevalent compared with European countries; the bicycle's share of local trips is two percent, car trips is 44%, and motorcycle trips is 53% in Taipei (Ku, 2006) compared with 30% for bike trips in the Netherlands, 20% in Denmark, 12% in Germany, and ten percent in Switzerland. Thus, the promotion of bicycling as an alternative to motorized transportation has a long way to go in Taiwan. There are 23 million residents in Taiwan, six million own cars and 13 million motorcycles; however, only own 1.1 million bicycles, the average Taiwanese has only 0.05 bicycles per person, compared with an average resident having 1.6 bicycles in the Netherlands. Hou (2005) pointed out the bikeway development in Taiwan must been made and improved.

Taiwan is increasing investment in the boom in bicycle tourism, and both central and local governments have been trying to stimulate the development of bicycle tourism and recreational bicycling (Chang & Chang, 2005), however; Huang, Shiue and Lin (1999) and Hou (2005) have indicated that the Taiwanese government has neglected the benefits of bicycling and paid little attention to bicycle facilities. According to the Environmental Protection Administration (EPA), Executive Yuan, R.O.C. (1997), the doubling of bike trips would save about one to three million US dollars on energy costs and improved fitness levels, reduce air pollution, and decrease energy use. Therefore, the Taiwanese government needs to pay more attention about the bicycling issue. By the year of 2008, the Taiwanese government expects to build 1,200 km of bicycle paths and promote citizens to participate in bicycling.

Purposes of the Study

The objectives of this study are to answer the following questions: the general situation of bicycle commuters; investigating whether recreational cyclist will bicycle commute or not; the constraints they face when bicycle commuting; the motivations for why they choose to bicycle commute; the benefits created by bicycle commuting; and hence propose how to improve the Taiwanese bicycle commuting situation.

This research will be divided into two parts. The first part is the review of the literature and the other part is the questionnaire design. This research aims to use the literature review to analyze bicycle commuting conditions in Taiwan, bicycle commuting conditions in foreign countries, and then, identify the bicycle commuting conditions in Taiwan and foreign countries. Finally, we can then explore the bicycle commuting problems and devise a questionnaire by the analysis. In the second part we will investigate bicycle commuting conditions, the motivation for choosing bicycle commute, bicycle commuting problems and the reasons for the high number of non-cycling commuters.

Research Questions

The researcher proposed four research questions according to the purposes of the study:

1. Do recreational cyclists also use their bicycles as a means for commuting?

2. If recreational cyclists do not also use their bicycles to commute, what are their reasons?

3. What are the motivations of recreation cyclists taking bicycles as their means for commuting?

4. How can recreational cyclists be encouraged to become bicycle commuters?

Definition of Terms

Bicycle Commuting

'''Bicycle commuting''' is the act of commuting to work or school by bicycle, a common form of utility bicycling rather than sport bicycling.

Bicycle commuter

In this study, the term of bicycle commuter was defined as one that used a bicycle at least once per week, for three months for at least half of the year.

Recreational cyclist

Recreational cyclist was defined as a person who joins the bicycle club or participates in bicycle activities.

Research Process

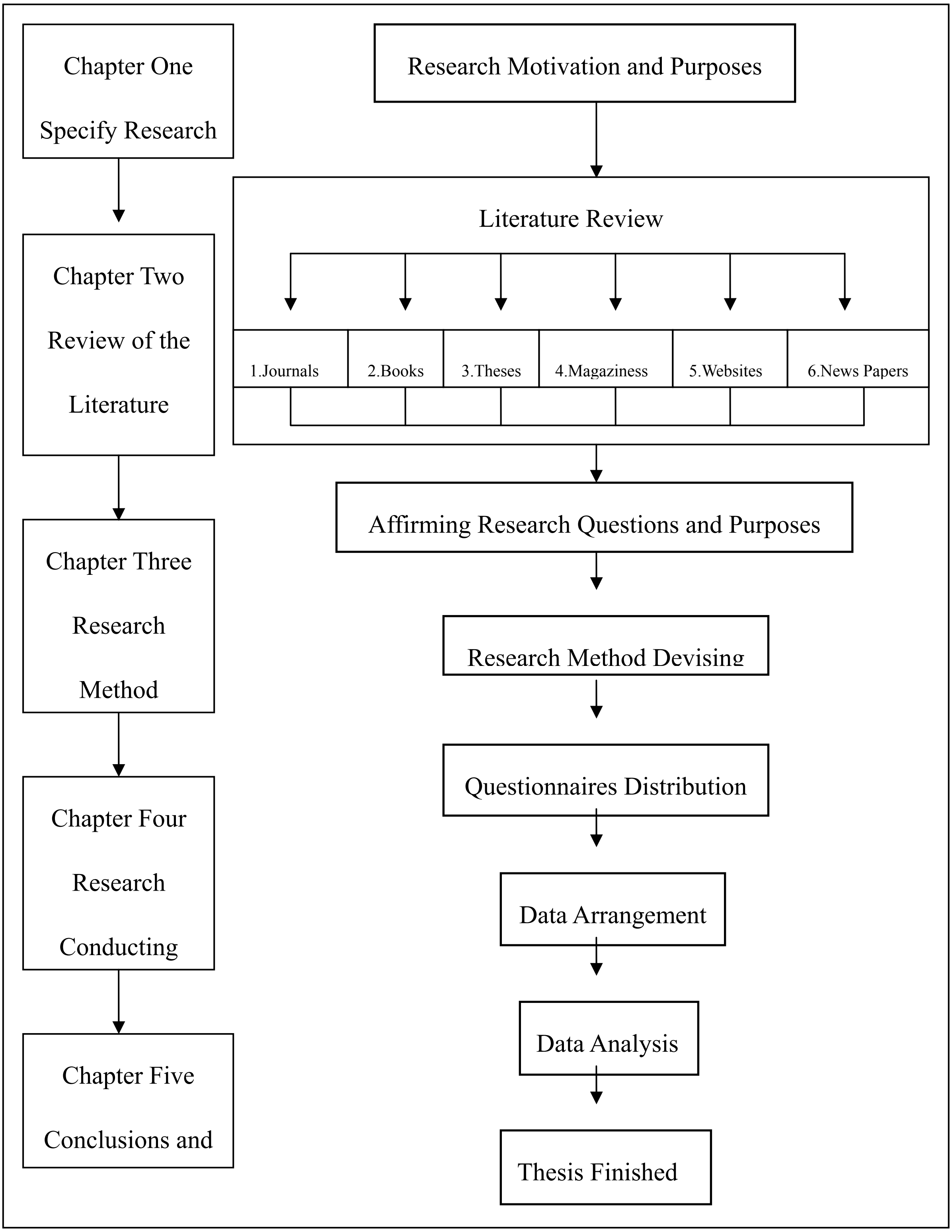


Figure 1. Research process.

Chapter 2

REVIEW OF THE LITERATURE

The Importance and Benefits of Bicycling

Currently, there is a global energy crisis as well as an air pollution problem (Wu, 2004), and Dill and Carr (2003) and Lohr (1999) agreed that with growing concerns over traffic congestion and vehicle pollution, motor vehicle transport also accelerates global warming through greenhouse gas emissions, increases habitat loss and may impair social contact in the neighborhood (Mason, 2000), and motor vehicle dependency impacts on individual health, public health and the environment (Hamer, 1999). Thus, public policy makers are increasingly promoting bicycling as an alternative for commuting and other utilitarian trip purposes. Thus, bicycling is a good mode of transportation in modern society, as it is an affordable and feasible solution to the traffic congestion and vehicle pollution problem.

Kazimee (n.d.) accomplished a paper about twenty five things to do to make an urban neighborhood sustainable. One of the twenty five things is to provide for bicyclists priority connections. He claimed that bikeways and walkways are critical to enhancing a more personal/pedestrian sense of community. These bikeways and walkways should connect to convenient transit stops and should have continuous pavement patterns across driveways and streets. Pedestrian/bike connections are far more energy-and cost-efficient than auto dependent access. They can provide ample bike parking and reduce auto services to a minimum. These sustainable design guidelines are an effective tool for demonstrating the theory, quality and application of a sustainable design to an urban community.

Multiple Functions of Bicycle

The bicycle is one of the first transportation vehicles in our industrial society. The composition of a bicycle is simple, but it can satisfy a variety of needs for the cyclists and can increase transport efficiency (Liao, 2000). The bicycle functions depend on the users rather than the bicycle itself. Not only they can be used for recreation and transportation, but they can also be used for racing or commuting. Xie (1999) stated that bicycle commuting is not common in highly developed cities. Moreover cycling has been moving toward sports and leisure rather than a means of commuting. Most of the Taiwanese used bicycles as a major form of transportation before 1960 (Hsieh, 2002); however, motorized vehicles have taken the role of bicycles in recent years. Though bicycle commuting is declining, Cheng (2005) observed that the population using cycling as a form of recreation is gradually increasing.

Ritchie (1998) remarked that the emerging trend of the bicycle is an important leisure and recreational transportation mode. Besides, Krizek and Roland (n.d.) claimed that on-street bicycle lanes usually comprise a critical backbone of a city’s overall bicycle plan, for both recreation and commuting. Papon (2001) observed that the bike fleet has increased as much as the car fleet, but it is less uniformly distributed among households. Only three quarters of it is not used for transportation purposes, not at all, or for only recreation.

Various Kinds of Bicycles

The researcher roughly classified bicycles into seven categories. They are road bikes, utility bikes, mountain bikes, folding bikes, child bikes, electric bikes Source: Cox (2005) bikes. Each kind of bicycle has been distinguished by its function and specialty.

Table 1. *Types and definition of bicycles.*

Type of bicycle	Definition
Road bike	Designed for road bicycle racing: they are fast, lightweight and aerodynamic.
Utility bike	Designed for utility bicycling: commuting, shopping, and running errands in towns and cities.
Mountain bike	In contrast to road bicycles, are rugged enough for off-road riding. However, given their popularity and low cost, these bicycles are often ridden on the road.
Folding bike	A folding bicycle or folder is a type of bicycle that incorporates a number of hinges or joints, which may be lockable, that permit it to be folded into a more compact size, typically via folding one or more of the bicycle's components, most often the frame.
Child bike	Design for child and short-distance commuting.
Electric bike	Electric scooters are rising in popularity because of higher gasoline prices. Battery technology is rapidly improving making this form of transportation more practical.
Other	Other specific-built bikes such as BMX (Bicycle Moto-cross), tandem, recumbent bike.

Source: Wikipedia (2006), organized by the researcher

There are various kinds of bicycles consumers in Taiwan; they are workers, seniors, women and children, recreational users and those who bike for exercise. Jin (1999) observed that electric bikes is one trend of bicycle buyers. Electric bikes are not widespread in Taiwan because of its price, weight and battery; however, if the problem of electric bikes could be solved, they could be a future trend.

Table 2. *The strategy construction of bicycle industry in Taiwan.*

	Consumer market					
	Item	Worker	Senior	Woman and children	Recreation user	Exerciser
Product		●				
	All Terrain Bike	●				
	City bike	●	◦	◦		
	Touring bike				◦	
	Mountain Bike	●			◦	
	Road racing					◦
	Electric bike	●	●	●	●	

◦ : Past-oriented strategy ● : Future-oriented strategy

Source: Industrial Technology Information Services, organized by Jin (1999) translated by the researcher

The bicycle is an important means of transport in urban and rural areas. Forester (2005) claimed that bicycle commuting in modern society is competitive with six other modes of transportation. This includes local mass transit, second, all transportation in congested urban areas, third, walking, but very few trips, except in congested urban centers, it is purely walking trips, fourth, urban motor trips when congestion and inconvenient parking make motoring too slow and inconvenient, fifth, walking and local mass transit when those are the choices for those without immediate access to a car, sixth, motoring and walking to locations where car parking is by permit only and where the style of clothing is largely optional, as on many university campuses.

Taiwan is crowded with motorized vehicles similar to other developing countries. It is hard to find a parking space and the parking problem alone makes motorized transportation inconvenient. Therefore, bicycling in Taiwan should be promoted as an alternative way for urban commuting. This will hopefully reduce the problem of traffic congestion.

The Advantages of Bicycle Commuting

According to the previous review of the literature, the researcher concluded that bicycling is an environmentally-friendly mode of transportation. It requires no fuel and compared to motorized vehicles, it is more affordable. Moreover, when cyclists ride bicycles, no matter for transportation or recreation, they provide health benefits.

Demaio and Gifford (2004) concluded that bicycles have several advantages over other modes of public transportation for short-distance urban trips because they: first, can reach underserved destinations, second, require less infrastructure, third, are relatively inexpensive to purchase and maintain, fourth, generally do not add to vehicular congestion, fifth, do not create pollution in their operation, and sixth, provide the user with the added benefit of exercise.

Economic Benefit of Biking

An average automobile costs NT$600,000, an average motorcycle costs NT$50,000, while an average bicycle costs NT$3,000. In other words, a car is equal to 200 bicycles, and thus, commuting by bicycle is economical, feasible, and affordable (Yang & Chang, 2005), especially when compared with other motorized transport modes. Dora (1999) and Hillman (1997) also noted that commuting by bicycle is the most affordable, feasible, and dependable way for people to get the additional exercise they need.

According to Directorate-General of Budget, Accounting and Statistics (DBGAS), Executive Yuan, R.O. C. (2005), each Taiwanese spent on average purchases of transport equipment NT$1,339, average operation of transport equipment for NT$12,166, average NT$4,155 on purchased transportation, average NT$1,345 on insurance of transport equipment, and the total of an average of NT$19,015 were spent on transportation expenses in 2005. Hypothetically, an average Taiwanese travels 3,650 km per year, the average cost per kilometer is NT$5.21, Table 3 shows average transportation fees.

Table 3. *Transportation expense per Taiwanese in 2005.* Unit: NT

Purchases of transport equipment	NT$1,339
Operation of transport equipment	NT$12,166
Purchased transportation	NT$4,155
Insurance of transport equipment	NT$1,345
Total	NT$19,015
Cost per kilometer	NT$5.21

DBGAS, Executive Yuan, R.O. C. (2005)

Here, the researcher supposed that an average 1.6 liter car cost NT$600,000, and it could be used for ten years, and automobile tax (fuel tax, license tax) costs NT$11,920 [Directorate General of Highways (DGH), M.O.T.C., 2007] annually, and automobile insurance costs NT$4,922 (DBGAS, 2007) annually, while repairs and maintenance (lubricant, tire) cost NT$3,000 annually, and a liter of 95 unleaded petroleum could run ten km. Hypothetically, an average Taiwanese travels 3,650 km per year, and Table 4 shows the car transportation fees.

Again, the researcher supposed that an average 125c.c. motorcycle cost NT$50,000, and it be could last for ten years. Motorcycle tax (fuel tax, license tax) cost NT$900 (DGH, 2007) annually, motorcycle insurance cost NT$767 (South China Insurance, 2007) annually, repairs and maintenance (lubricant, tire) cost NT$1,200 annually, and a liter of 95 unleaded petroleum could run 22.5 km (DGBAS, 2005). Hypothetically, an average Taiwanese travels 3,650 km per year, and Table 4 shows the motorcycle transportation fees.

On the other hand, hypothesized that all Taiwanese take that bicycle as their commute mode, the transportation expense will be like this: a bicycle could last for five years and it cost NT$3,000, repairs and maintenance (chain and tire) cost NT$500 annually, Hypothetically, an average Taiwanese travels 3,650 km per year, and Table 4 shows the bicycle transportation fees.

On the individual aspect, a car driver turns into a bicycle commuter, it is possible to save NT$88,962 (90,062 deduct from 1,100) annually; motorcycle commute mode turns into a bicycle commuter, it is possible to save NT$10,795 annually. The data can be found in Table 4.

Table 4. *The cost of private transportation.* Unit: NT$

Automobile purchase (600,000 divided by 10 yrs)	60,000	Motorcycle purchase (50,000 divided by 10 yrs)	5,000	Bicycle purchase (3,000 divided by 5 yrs)	600
Automobile tax (fuel tax, license tax)	11,920	Motorcycle tax (fuel tax, license tax)	900		
Automobile insurance	4,922	Motorcycle insurance	767		
Repair and maintenance (lubricant, tire)	3,000	Repair and maintenance (lubricant, tire)	1,200	Repair and maintenance (lubricant, tire)	500
Fuel expense (3,650 multiplied by 28 and divided by 10)	10,220	Fuel expense (3,650 multiplied by 28 and divided by 22.5)	4,088		
Total	90,062	Total	11,955	Total	1,100
Cost per kilometer	24.67	Cost per kilometer	3.28	Cost per kilometer	0.30

On the view of mass transportation mode, Taipei union bus costs two NT dollars per kilometer, 3,650 km commute distance will cost NT$7,300 annually; Taipei MRT costs three NT dollars per kilometer, 3,650 km commute distance will take NT$10,950 annually; Kuo-kuang bus costs NT$1.6 per kilometer, 3,650 km commute distance will take 5,840 annually; Taiwan Railway costs NT$2.3 per kilometer; 3,650 km commute distance will take NT$8,395 annually.

Table 5. *The direct cost of mass transportation.* Unit: NT$

Mass transportation mode	Taipei union bus	Taipei Mass Rapid Transit (MRT)	Kuo-kuang bus	Taiwan railway
Ticket	NT$15, 7 km	NT$45,15 km	NT$255, 160 km	NT$375, 160 km
Fuel cost per kilometer	2/km	3/km	1.6/km	2.3/km
Transportation expense per year (3,650 km)	7,300	10,950	5,840	8,395

Source: C. X. Chang (2004)

Walking is the most economical commute means at NT$0 per kilometer; nevertheless, an average walking speed is approximately five km per hour, this means that ten km round trip will take two hours for the commute distance. In developing countries like Taiwan, two hours to commute is nearly impossible, not to mention there are seldom sidewalks in most urban areas for pedestrians.

Bicycling is the second most economical transportation mode at NT$0.30 per kilometer, however, five km of commute distance could be finished within 20 minutes. If the average cycling speed is about 20 km per hour, it is four times faster than walking. Bike and ride is a good transport method for long distance commuting and it is possible to bicycle to bus stations, train stations, or MRT stations, and carry bicycles onto the bus or train. The data can be found in Table 6.

Table 6. *The direct cost of transportation.* Unit: NT$

Transport means	The direct cost of transportation
Average transportation cost per Taiwanese	5.21/km
Walking	0/km
Bicycling	0.30/km
Motorcycle	3.28/km
Car	24.67/km
Taipei union bus	2/km
Taipei Mass Rapid Transit(MRT)	3/km
Kuo-kuang bus	1.6/km
Taiwan Railway	2.3/km

The total of shorter than ten km round way commute distance accounted for 58.2% in 2003, and the total of shorter than ten km round way commute distance accounted for 49% in 2005 (DGBAS, 2005). Hypothetically, all 22,733,839 residents (DGBAS, 2005) multiplied by average transportation NT$19,015, it is equaled to NT$432,283,948,585; if every Taiwanese use car as transport mode it will take 22,733,839 multiplied by 90,062, it is equal to NT$2,047,455,008,374; all motorcycle commute mode took 22,733,839 multiplied by 11,985, it is equal to NT$27,246,506,415;all MRT commute mode took 22,733,839 multiplied by all bicycle commute mode took 22,733,839 multiplied by 1,100, it is equal to NT$25,007,222,900. The data can be found in Table 7.

Table 7. *Direct cost of different Taiwanese transportation expenses.* Unit: NT$

Commute mode	Direct cost of Taiwanese transportation expense
Average Taiwanese transport expense (DGBAS, 2005)	432,283,948,585
Car	2,047,455,008,374
Motorcycle	272,465,060,415
MRT (Mass rapid transit)	248,935,537,050
Bicycle	25,007,222,900

On the government aspect, possibly all Taiwanese changed car commute mode into bicycle commute mode, it could save NT$2,294,912,845,889 (2,047,455,008,374 deduct from 25,007,222,900) annually; all Taiwanese changed motorcycle commute mode into bicycle commute mode, it could save NT$247,457,837,515 (272,465,060,415 deduct from 25,007,222,900) annually.

Health Benefits of Biking

Physically activity is becoming increasingly recognized as a lifestyle behavior with significant individual and population health benefits. For the past ten years, the evidence for the beneficial health effects of physical activity has been accumulating, demonstrating physical activity to be protective against cardiovascular and other chronic diseases, while implicating physical inactivity as a risk factor for these same diseases. Moreover, physical activity is beneficial for the mental health of an individual. These benefits can be obtained from 30 minutes of moderate intensity physical activity on most days of the week, and the benefits are dose-dependent; physical activity of longer duration and greater intensity reap greater benefits (Ling et al., 2002). Cycling improves cardiovascular fitness. It uses all the major muscle groups, strengthens bones and helps prevent osteoporosis, improves circulation, reduces cholesterol levels, relieves the effects of rheumatoid arthritis and, like all physical activity, helps people cope better with stress (Rissel, 2003).

In Wadhwa's (1998) study, he discovered that health was cited by almost every respondent as a reason for using a bicycle, and 70 percent cited it as the most important reason. The inexpensiveness of a bicycle and ecological considerations also were cited as other reasons for using a bicycle by about three-quarters of the respondents. Being the only alternative was cited by less than half of the respondents, although 60 percent of the respondents did not have sole access to a car.

Dora (1999) observed that cycling can bring major health benefits. For example, half an hour a day can halve the risk of developing heart disease. This is equivalent to the effect of not smoking and is valid for most of the population, who do very little physical activity. Even if spread over two or tree shorter episodes, this amount of activity can also halve the risk of developing diabetes, reduce blood pressure (equivalent to the effect of taking antihypertensive drugs), and improve functional capacity.

Bicycle commuting has many advantages. For example, while commuting by bicycle to the office or to school, the cyclist gets aerobic exercise at the same time (Zheng, 1997). Many fitness experts have asserted that aerobic exercise could improve fitness levels. Dool (2003) added that it is also a critical means to reduce traffic congestion, air, and noise pollution.

The health-damaging and financial costs of physical inactivity represent a major public health problem, comparable to tobacco smoking, and a challenge to health promotion researchers to develop strategies to encourage physical activity. More bicycling as a means of transport is believed to be one of the few feasible options to increase the levels of physical activity among the general population. Furthermore, Killingsworth and Lamming (2001) remarked that bicycling is a better approach than promoting sports, aerobics, or weightlifting because structured activities only resonate with a small percentage of the population. All in all, bicycle commuting is one simple way to have a healthy body.

Bicycling to control weight

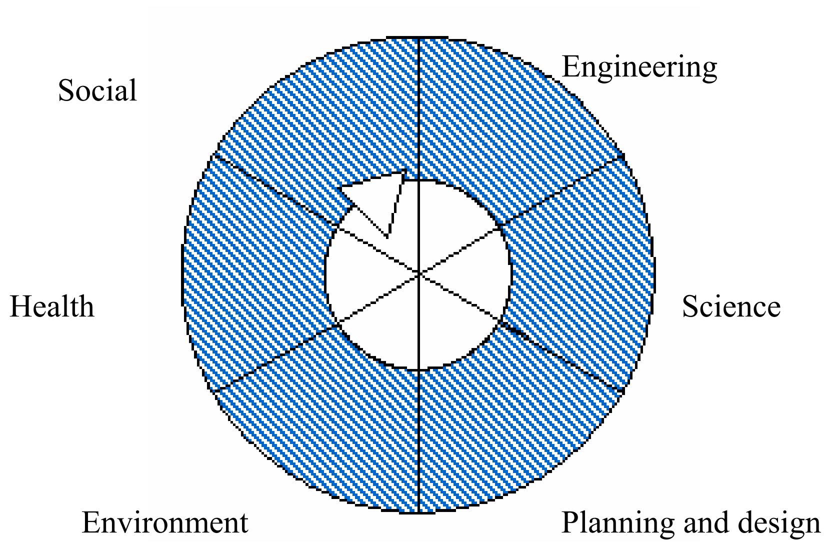
Running, swimming and cycling are major aerobic exercises. While commuting to the work place or school by bicycle, a ten km commute distance in an urban area takes approximately 40 minutes (five km one way for 20 mins), and this could infer that a 140 pound person could burn extra 341 (512 multiplied by 0.66) calories every bicycle commuting day. A regular bicycle commuter could burn extra 10,230 calories more than non-bicycle commuter monthly, so it is possible to lose 3 pounds if there is no change in the diet in the month. Table 8 shows exercise calorie consumption per hour.

Table 8. *The calorie consumption of different types exercise.*

Activity (one-hour duration)	Calories burned	
	140-to 150-pound person	170-to 180-pound person
Aerobic dancing	416-442	501-533
Backpacking	448-476	539-574
Badminton	288-306	347-369
Bicycling (outdoor)	512-544	616-656
Bicycling (Stationery)	48-476	539-574
Bowling	192-204	231-246
Canoeing	224-238	270-287
Dancing	288-306	347-369
Gardening	256-272	308-328
Golfing (carrying bag)	288-306	347-369
Hiking	384-408	462-492
Jogging, 5 mph	512-544	616-656

Racquetball	448-476	539-574
Rope jumping	640-680	770-820
Running, 8 mph	864-918	1,040-1,107
Skating (ice-or roller)	448-476	539-574
Skiing (cross-country)	512-544	616-656
Stair climbing	576-612	693-738
Swimming	384-408	462-492
Tennis	448-476	539-574
Volleyball	192-204	231-246
Walking, 2 mph	160-170	193-205
Walking, 3.5 mph	243-258	293-312

Source: MayoClinic.com



Source: Dool (2003)

Figure 2. The bicycle wheel – individual segments have formed a whole.

Dool (2003) concluded that bicycling is comprised of six factors: they are social, health, environment, engineering, science, and planning and design.

Bicycle, the Anti Air Pollution Transportation

Nowadays, air pollution is a critical concern, and road transportation accounted for 81 percent of Nitrogen Oxides (NO_x) emissions (diesels four percent; petroleum cars 34 percent and motorcycles 43 percent. Besides, road transportation accounted for approximately 98 percent of these pollutants: vehicles are responsible for 74 percent, motorcycles 21 percent and diesels three percent (Wang, n.d.).

Cars, trucks, buses, and other motor vehicles are playing an ever-increasing role in global climate change and air pollution worldwide. Land transport is causing serious environmental problems, not only in industrialized countries, but also in developing ones (Hmaidan, n.d.).

Motorized vehicles emit a variety of air pollutants that are known to be associated with adverse health effects. Common air pollutants emitted by motor vehicles include fine particles, nitrogen dioxide and Volatile Organic Compounds (VOCs). Exposure to fine particles is associated with short and long-term adverse health effects on the lungs and heart, including premature death (Chertok, Voulkelatos, Sheppeard & Rissel, 2004; Dora, 2003).

Dora (2003) estimated that a change in air pollution from the highest to the lowest amounts was documented in studies in the United States for the long term effects of air pollution (particulate matter smaller than 2.5 μm around 30 $\mu g/m^3$ of air and 10 $\mu g/m^3$ of air) could conceivably be associated with a change in life expectancy in the order of years. Another estimate suggests that Dutch men could gain over a year in life expectancy from a reduction in the concentration of particulate matter smaller than 2.5 μm to around 10 $\mu g/m^3$ of air.

Particulate matter is also associated with increases in respiratory symptoms, greater use of drug treatments in people with asthma, reduction in lung function, and admissions to hospital for respiratory and cardiovascular disease. No threshold could be identified below which health effects were not found. In northern Europe, about 40% of particulate matter comes from traffic. Small particles can get indoors freely and can travel long distances, so neither the indoor environment nor distance from roads offers much protection (Dora, 2003).

Most of the Taiwanese believe riding bicycles will expose the rider to the polluted air condition, and endanger their health. However Chertok et al. (2004) observed that international studies have consistently found that exposure to air pollutants is higher inside cars than outside. In their study, they found exposure the lowest levels of exposure to Benzene, Toluene, Ethyl and Xylenes (BTEX) were found for train commuters, followed by pedestrian, cyclists, bus commuters, and the highest for the driver of cars. Walking and bicycling are likely to be the most beneficial when routes are away from busy car routes, although even on the same roadway and taking into account increased respiration due to activity. Cyclists in Amsterdam still had 2-3 times lower exposure to pollutants than the drivers of cars.

From 1997 to 2007, the grand total of motorized vehicles has increased drastically from 15,345,745 to 20,368,314, that was 5,022,569 registered vehicles accounted for 32.8% of grand total motorized vehicle growth rate; private passenger car has increased from 4,302,622 to 5,568,590, that was 1,265,968 accounted for 29.4% of private passenger car growth rate; motorcycle has increased from 10,051,613 to 13,602,531, that was 3,550,918 accounted for 35.3% of motorcycle growth rate. Table 9 shows the number of registered motor vehicles in Taiwan-fuchien area.

Table 9. *Number of Registered Motor Vehicles in Taiwan-fuchien Area.*

End of Year and Month	Grand Total	Bus			Truck			Passenger Car	
		Subtotal	Private	Business	Subtotal	Private	Business	Subtotal	Private
1997	15,345,745	22,743	3,269	19,474	158,000	87,702	74,298	4,411,911	4,302,622
1998	15,939,135	22,871	3,088	19,783	156,239	81,953	74,286	4,545,488	4,433,195
1999	16,317,768	23,798	2,878	20,920	152,878	79,434	73,444	4,509,430	4,401,730
2000	17,022,689	23,923	2,748	21,175	155,623	81,003	74,620	4,716,217	4,608,960
2001	17,465,037	24,053	2,580	21,473	155,140	81,813	73,327	4,825,581	4,720,641
2002	17,906,957	25,079	2,326	22,753	155,805	82,649	73,156	4,989,336	4,888,050
2003	18,500,658	25,628	2,196	23,432	157,156	83,912	73,244	5,169,733	5,071,981
2004	19,183,136	26,453	2,042	24,411	160,460	85,662	74,798	5,390,848	5,262,693
2005	19,862,807	26,963	1,883	25,084	164,248	88,049	76,199	5,634,362	5,495,693
2006	20,307,197	27,522	1,812	25,710	166,211	90,142	76,069	5,698,324	5,555,507
Feb.	19,938,794	27,089	1,873	25,216	164,307	88,091	76,216	5,656,743	5,516,834
Mar.	19,971,953	27,069	1,843	25,226	164,627	88,305	76,322	5,660,472	5,510,911
Apr.	19,996,131	27,162	1,832	25,330	164,796	88,453	76,343	5,662,945	5,522,093
May.	20,032,243	27,175	1,838	25,337	165,062	88,698	76,364	5,671,232	5,529,699
Jun.	20,071,354	22,197	1,839	25,358	165,348	89,007	76,341	5,676,052	5,533,869
July.	20,120,824	27,326	1,825	25,501	165,481	89,162	76,319	5,686,467	5,543,658
Aug.	20,155,742	27,373	1,820	25,553	165,727	89,268	76,459	5,683,635	5,541,144
Sept.	20,220,450	27,429	1,814	25,615	165,877	89,414	76,463	5,689,371	5,546,826
Oct.	20,252,522	27,452	1,813	25,639	165,953	89,610	76,343	5,687,845	5,545,278
Nov.	20,286,685	27,504	1,812	25,692	166,036	89,844	76,192	5,693,346	5,550,676
Dec.	20,307,197	27,522	1,812	25,710	166,211	90,142	76,069	5,698,324	5,555,507
2007	20,368,314	27,608	1,808	25,800	165,985	90,383	75,602	5,712,766	5,568,590
Jan.	20,341,288	27,433	1,807	25,626	166,024	90,333	75,691	5,708,548	5,565,022
Feb.	20,368,314	27,608	1,808	25,800	165,985	90,383	75,602	5,712,766	5,568,590

Table 9.(continued) *Number of Registered Motor Vehicles in Taiwan-fuchien Area.*

End of Year and Month	Passenger Car		Pick-up Truck (Light Truck)			Specially Constructed Vehicles	Motorcycle		
	Business	Taxi	Subtotal	Private	Business		Subtotal	Heavy-type	Light-type
1997	109,289	109,289	655,410	648,713	6,697	46,066	10,051,613	5,875,734	4,175,879
1998	112,293	112,293	657,855	650,592	7,263	47,642	10,529,040	6,199,613	4,329,427
1999	107,700	107,700	627,034	618,943	8,091	46,159	10,958,469	6,496,189	4,462,280
2000	107,257	107,257	652,963	643,796	9,167	50,791	11,423,172	6,848,116	4,575,056
2001	104,940	104,940	675,533	665,718	9,815	51,528	11,733,202	7,131,438	4,601,764
2002	101,286	101,286	700,978	690,750	10,228	52,002	11,983,757	7,386,784	4,596,973
2003	97,752	97,752	728,624	717,915	10,709	52,653	12,366,864	7,759,650	4,607,214
2004	128,155	95,665	758,809	743,939	14,870	52,616	12,793,950	8,239,700	4,554,250
2005	138,669	94,278	789,222	770,659	18,563	52,743	13,195,265	8,746,286	4,448,979
2006	142,817	92,418	805,590	783,979	21,611	52,522	13,557,028	9,225,155	4,331,873
Feb.	139,909	94,314	791,827	772,771	19,056	52,659	13,246,169	8,812,061	4,434,108
Mar.	140,561	94,331	793,979	774,510	19,469	52,665	13,273,141	8,850,627	4,422,514
Apr.	140,852	94,203	796,050	776,245	19,805	52,668	13,292,510	8,878,655	4,413,855
May	141,533	94,212	798,294	778,076	20,218	52,666	13,317,814	8,913,032	4,404,782
June	142,183	94,040	799,704	779,297	20,407	52,664	13,350,389	8,955,526	4,394,863
July	142,809	93,807	801,221	780,634	20,587	52,716	13,387,613	9,002,158	4,385,455
Aug.	142,491	93,572	801,980	781,218	20,762	52,799	13,424,228	9,049,314	4,374,914
Sept.	142,545	93,306	803,861	782,688	21,173	52,812	13,481,100	9,115,163	4,365,937
Oct.	142,567	93,049	804,317	782,968	21,349	52,696	13,514,259	9,159,118	4,355,141
Nov.	142,670	92,723	805,164	783,656	21,508	52,567	13,542,068	9,198,190	4,343,878
Dec.	142,817	92,418	805,590	783,979	21,611	52,522	13,557,028	9,225,155	4,331,873
2007	144,176	92,168	806,811	784,793	22,018	52,613	13,602,531	9,291,284	4,311,247
Jan.	143,526	92,246	806,747	784,800	21,947	52,651	13,579,885	9,260,073	4,319,812
Feb.	144,176	92,168	806,811	784,793	22,018	52,613	13,602,531	9,291,284	4,311,247

Source: DGBAS, Executive Yuan, R.O. C. (2005)

Motorcycle, the main transportation in Taiwan

There are the total of 13,160,350 registered motorcycles in Taiwan, and the Taiwanese population was 22,733,839 people in 2005. This means that an average Taiwanese had 0.58 motorcycle per person. Table 10 shows the registered motorcycles distribution in Taiwan.

Table 10. *Registered motorcycles distribution in Taiwan.*

Location	Registered motorcycles	Percent	Location	Registered motorcycles	Percent
Total	13,160,350	100.0	Total	13,160,350	100.0
Taipei city	1,030,972	7.8	Yunlin county	447,250	3.4
Kaohsiung city	1,128,640	8.6	Chiayi county	335,874	2.6
Taiwan province	11,000,738	83.6	Tainan county	723,786	5.5
Taipei county	2,035,899	15.5	Kaohsiung county	910,680	6.9
Yilan county	270,758	2.1	Pingtung county	636,487	4.8
Taoyuan county	926,342	7.0	Taitung county	163,131	1.2
Hsinchu county	231,817	1.8	Hualien county	223,292	1.7
Miaoli county	314,258	2.4	Penghu county	60,278	0.5
Taichung County	902,938	6.9	Keelung city	176,375	1.3
Changhua county	828,130	6.3	Hsinchu city	230,144	1.7
Nantou county	316,986	2.4	Taichung city	562,011	4.3
Chiayi city	182,422	1.4	Tainan city	521,880	1.4

Source: DBGAS, Executive Yuan, R.O. C. (2005)

Average everyday motorcycle commutes distance

29.3% of motorcycle commuters commute distance is longer than 20 km, follow up by the shorter than one km accounting for 15.7%.

The total of shorter than ten km commute distance accounted for 58.2% in 2003, and the total of shorter than ten km commute distance accounted for 49% in 2005. It is possible to conclude that shorter than five km (round way for ten km) motorcycle commute distance accounted for the majority of motorcycle trips.

Table 11. *Average everyday motorcycle commuting distance (round way).* Unit:%

Item	Total	<1km	1-3km	3-5km	5-10km	10-15km	15-20km	>20km	Average
2003	100.0	8.6	17.7	15.5	16.4	12.1	9.2	20.5	12.2
2005	100.0	7.0	15.7	12.1	14.2	12.2	9.4	29.3	15.5
Location									
Taipei city	100.0	6.3	10.9	10.0	12.5	14.4	11.3	34.6	17.8
Kaohsiung city	100.0	7.0	16.5	9.4	16.9	10.6	7.3	32.2	16.2
Taiwan province	100.0	7.1	16.2	12.7	14.1	12.1	9.4	28.3	15.2
Purpose									
Commuting to work	100.0	3.2	12.0	11.3	15.1	13.5	11.8	33.2	17.2
Commuting to school	100.0	3.2	10.3	8.3	16.1	13.2	11.8	37.1	18.2
Business	100.0	5.2	16.2	14.2	12.3	13.5	8.0	30.4	16.0
Pick up family	100.0	11.7	23.6	16.4	13.9	12.7	6.3	15.4	10.2
Shopping	100.0	15.4	28.5	16.2	16.4	8.9	5.7	8.8	7.4
Recreation and travel	100.0	7.3	7.4	8.0	9.6	8.1	7.5	52.0	24.1

Source: DBGAS, Executive Yuan, R.O. C. (2005)

As many transportation scholars/experts all over the world have pointed out, bicycle transport is regarded as a “green” mode of transportation because bicycles emit no pollution (Liu, Wei, Guan & Ma, 2003). Hsieh (2002) claimed that bicycling is an environmental friendly mode of transportation. There is an environmentally-friendly score chart below. Bicycling and walking are ranked as number one.

Table 12. *Bicycle, the Green Transportation.*

Transportation	Environmental-friendly score	Ranking	Transportation	Environmental-friendly score	Ranking
Walking	53	1	Private Electric Car	34	9
Bicycling	53	1	Gasoline Taxi	33	10
Mass Rapid Transit (MRT)	50	2	Private Gasoline Car	20	11
Electric Bus	50	2	Taiwan Railway	9	12
Light Rail	49	3	Electric Elevator	2	13
Electric Car	46	4	Bus	-34	14
Electric motorcycle	43	5	Taxi	-47	15
Electric bicycle	42	6	Truck	-48	16
Taiwan High Speed Rail	38	7	Car	-49	17
Gasoline Bus	35	8	Motorcycle	-53	18

Source: Chang (2000) translated by the researcher

There are 23 million Taiwanese with 13 million motorcycles and six million automobiles (Chang & Wu, 2005). An average Taiwanese owns 0.78 motorized vehicles; however, these two motorized vehicles are listed as the second to last and last on the environmentally-friendly ranking scale. However bicycles, as a mode of transportation, are owned by only one in 20 people in Taiwan. The Taiwanese government should promote bicycling as a means of commuting or recreation to reduce air pollution, decrease traffic congestion, and promote a healthy lifestyle.

There are a variety of bicycle facilities; the American Association of State Highway and Transportation Officials (AASHTO) have classified bicycle facilities into seven categories.

Table 13. *Examples of Bicycle Facilities.*

Facility	Description
Bikeway	Any road, path, or way which in some manner is specifically designated as being open to bicycle travel, regardless of whether such facilities are designated for the exclusive use of bicycles or are to be shared with other transportation modes.
 Bicycle Path (Taichung County)	A bikeway physically separated from motorized vehicular traffic by an open space or barrier and either within the highway right-of-way or within an independent right-of-way.
 Bicycle Lane (Taitung County)	A portion of a roadway which has been designated by striping, signing and pavements marking for the preferential or exclusive use of the bicyclist.

Bicycle Route (Tainan City)

A segment of a System of bikeways designated by the jurisdiction having authority with appropriate directional and informational markers, with or without a specific bicycle route number.

Shared Roadway (Taichung City)

Any roadway upon which a bicycle lane is not designated and which may be legally used by bicycles regardless of whether such facility is specifically designated as a bikeway.

Signing and Marking (Taipei City)

Visual aids which alert cyclists to conflicts and indicate directions, destinations, distances, route numbers and names of crossing streets.

Parking facilities provided at trip origin and destinations including amenities such as bicycle lockers or racks.

Bicycle Parking (Kaohsiung City)

Bicycle Parking Shed (Taipei City)

Source: The AASHTO Guide, 1991; photo by the researcher

Summary

Taiwan is known as the kingdom of bicycle manufacturing; however, 95% of the bicycles are used for exports. Compared to motorized vehicles, the bicycle is cheap and economical; however, bicycles are light and have no identification on them. They can easily be stolen by thieves which may reduce the public's intention to buy and ride bicycles.

The bicycle has various functions; it can be used for recreation, competition and commuting purposes. Due to the elevation of Taiwanese GDP, the motorized vehicle ownership is getting higher; the bicycle has changed its status from a commuting tool to a recreational toy. The Taiwanese government should encourage the public to get involved in recreational bicycling; however, it should also support people to use bicycles as a form of commuting. This would elevate the bicycle usage rate and improve the air quality in Taiwan.

According to Chertok et al. (2004), bicycle commuters inhale less polluted air than those who drive cars, however, the commuting situation is different because there are commuting bikeways in foreign countries while Taiwan does not such bikeways. The Taiwanese believe that cyclists inhale more polluted air than those who drive cars. Although bicycling will improve fitness levels, people in Taiwan believe polluted air will endanger their respiratory systems. Often it is people who do not want to use the bicycle as a means of commuting who spread misinformation about the negative health aspects of cyclists breathing polluted air.

Global warming, oil crises and roadway congestion, all these problems heighten the problem of motorized vehicles usage; however, the Taiwanese bicycling policy still has not yet been carried out. Moreover, though people who do want to take bicycles as a mean of transport are often discouraged in Taiwan because of polluted air, safety concerns and lack of bikeways. All these problems reduce people’s inclination to bicycle commuting.

Taiwan is a crowded and a small island, and most of the people’s commute distance is shorter than five km, and thus is suitable for bicycle commuting. Building commuting bikeways is a desirable approach to elevate bicycle usage, and reduce the air pollution that is causes by motorized vehicles; however, the problem is how and where to build commuting bikeways in such a crowded island. Besides, Taiwanese have gotten accustomed to relying on motorized vehicles, and the question is, will they change their commuting behavior when there are commuting bikeways.

Current Bicycling Conditions and the Motivation for Bicycle Commuting

The development of bicycle lanes in Taiwan originated in Taipei and it is based on the purpose of transport function. In 1991, one-metered bicycle lanes were constructed on both sides of the traffic islands. Early in the testing operation stage it failed because the cyclists caused problems with the pedestrians (Chang & Chang 2003).

Forester (2005) defined transportation bicycling. It means that bicycles are involved in areas and along routes with motor traffic involves bicycling. Furthermore, Forester (2005) concluded cyclists can be voluntary and involuntary cyclists.

Table 14. *Types of Cyclists.*

Types of cyclists	Characteristics	Examples
Involuntary cyclist	Those who have little other choice for personal transportation.	Under driving age, without sufficient money to afford motoring.
Voluntary cyclist	Do not respond to the niche considerations above.	Do not have the typical exaggerated fear of motor traffic.

Source: Forester (2005)

Current Bikeway System in Taiwan

1. The bikeway development in Taiwan is a top-down procedure, as the central government builds the bicycle facilities and citizens use them as compared with foreign countries' bottom-up procedure, where bicycle facilities were built to satisfy the need of cyclists.

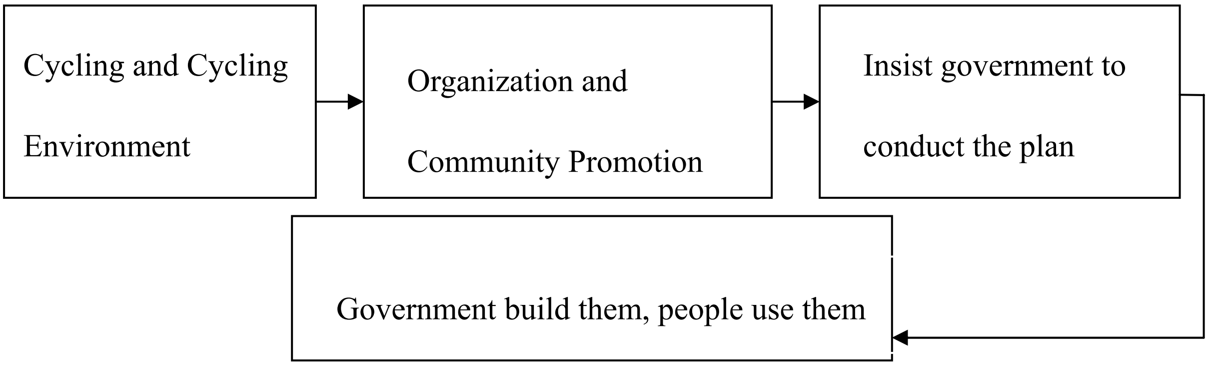


Figure 3. The Overseas Bicycle Tourism Model. Source: Chang & Chang (2003)

2. The Taiwanese government usually stresses protecting the environment, such as by promoting civil engineering work and landscape design but has neglected the characteristics of recreational cyclists and their environmental preferences (H. W. Chang, 2004).

3. There are three kinds of bikeways in Taiwan.

(1) Bike path on rights-of-way separate from roadways. This is the safest one.

(2) Bike lanes on roadways, separated from motor traffic by a barrier or a painted line.

(3) Bike routes on road shared with cars or sidewalks shared with pedestrians.

(1) Bike path (2) Bike lane (3) Bike route

4. Bikeways in Taiwan shared by bicyclists, hikers, and joggers present the unusual traffic flow situation, and results in a conflict among the three types of users (Yen, Shuien, Shiu, Chiao & Liauo, 2002; Wang, 2004).

5. Bikeways in Taiwan are segregated from major traffic, compared with the integration of bicycle lanes into the existing environment in foreign countries.

6. There are 98 bikeways in Taiwan. The bikeways in Taiwan are a form of sports development, which is used for recreation and rarely for transportation, compared with sustainable development of green transportation mode and green products in foreign countries (Chinese Institute of Landscape Architect in Taiwan, 2002). In most bicycling-oriented European countries roughly two-thirds of trips are utilitarian trips and one-third recreational (Tolley, 1997; Zegeer, 1994).

7. Recreational cyclists in national scenic bikeways and local bike lanes have different preferences. There are two kinds of recreational bikeways in Taiwan. The first are bikeways located in national scenic areas which are built by the central government. The other kind of bikeways are located in local areas and built by the local government. The two types of users differ in terms of accessibility, activity purpose, and attraction (Chang & Chang, 2005).

8. Bicycle parking has been a transportation problem, especially at Mass Rapid Transit (MRT) stations (Tsao & Lin, 2004). Wadhwa (1998) noted that a U.S study found the lack of secure parking facilities and pavement surface conditions to be the principal deterrents to bicycle commuting, while increased exposure to air pollution, traffic and weather were considered to be mildly discouraging factors.

9. Professional cyclists' needs are different with recreational cyclists' needs. According to the study of K. H. Chang (2004), he wrote that recreational cyclists regard the following three as most important: safety, bicycle lanes and low flow of traffic. The three least important ones are hilliness, satisfying long routes and accommodation facilities. Professional cyclists deem the following three as important: safety, abundant travel resources and hilliness. They believe the following three are the least important: flat terrain, friendly residents and bicycle activities.

10. Men account for most of the bicycle path usage (Krizek, Johnson, Tilahun, 2004; Liao, 2003). Most of the cyclists are 20-30 years old, and most are college-level students. Women make shorter bicycle trips than men (Lo & Lin, 2006).

Bikeways in Taiwan are a sport-development phenomena compared with foreign countries' commuting bikeways, and according to the Chinese Institute of Landscape Architect in Taiwan (2002), there are 80 bikeways in Taiwan. 77 of the bikeways are for leisure and recreational use, while only 3 of the bikeways are for bicycle commuting. Besides, the cyclist percentage in Taiwan is much less than in other foreign countries'. The most effective way to reduce traffic congestion and air-pollution is by bicycle commuting rather than recreational bicycling. The government or policy makers in Taiwan should focus on the development of commuting bikeways.

Summary

The development of bikeways in Taiwan was based on the purpose of bicycle commuting in 1991. The Chinese Institute of Landscape Architect in Taiwan (2002) conducted a survey which showed that there were a total of 80 bikeways, and three of them were for bicycle commuting. However, the researcher made a phone call to the Sport Council of Executive Yuan, and the officer responded that there was not a single commuting bikeway in Taiwan in 2006. At first, the bikeway development was based on the purpose of bicycle commuting, and now there is not a single commuting bikeway in Taiwan, so the bicycle commuting situation has gotten progressively worse. On the other hand, the recreational bikeways have increased rapidly to 98 bikeways in 2006. We can thus tell that the bicycle policy in Taiwan pays less attention to bicycle commuting and strengthened its position on recreational bicycling.

In January 2007, the researcher toured Taiwan by bicycle in ten days, aiming to investigate the bicycle commuting situation in Taiwan. The researcher found that there are commuting bikeways in Taipei City, Tainan City, Kaohsiung City and Taitung City etc…, however, the utility rate of these bikeways are extremely poor. The researcher observed that the commuting bikeways are rough and not continuous, and these made the bikeway utility rate extremely poor.

One of the reasons that Taiwanese do not to bicycle commute is due to the lack of commuting bikeways. Nevertheless, even in big cities like Taipei or Kaohsiung, they did have commuting bikeways, and still bicycle commuting was not popular. According to the researcher’s observations, the researcher concluded: first, commuting bikeways are not continuous, some of the sections of the bikeway are filled with motorized vehicles, second, there are cars, motorcycle or even miscellaneous objects blocking the commuting bikeways, third, the pavement on the commuting bikeways are poor making riders uncomfortable, fourth, the commuting bikeways are set up in remote areas, and riding on them is an inconvenience to riders.

Global Bicycling Conditions and Bikeway Systems

Bicycling in foreign countries by those who enjoy bicycling has had its ups and downs. It was down in the 1920s, up in the Great Depression and until 1950, then down in the 1950s, up again in the 1960s and 1970s, coasted in the 1980s, and again rose in the 1990s (Forester, 2005). With the advent of the automobile and its widespread use, it appeared as though bicycling would have eventually disappeared by the 1960's. Papon (2001) said that walking and cycling have lost market shares in trips made in France for several decades. However, the gasoline crisis in 1973, the increased of the costs associated with owning an automobile, and the importance of personal fitness, all led to a resurgence of the bicycle (Lohr, 1999; K. H. Chang, 2004). Dora (2003) pointed out that reductions in cycling and walking have been reported in countries for which data are available. In the United Kingdom, cycling accounted for nearly 25% of all road traffic in 1951, but by 1994 this figure had fallen to just one percent.

Bicycling is a highly sustainable means of transportation and is used for both commuting and recreational purposes. Over the last two decades, the popularity of bicycling has increased tremendously among all age groups in most developed economies. However, this revival of bicycling has been mainly associated with recreational uses, in particular new forms of bicycling such as mountain biking, while commuting to work has no increased at the same rate (Brandenburg, Matzarakis, & Arnberger, 2004).

The Dutch area is about 41,000 square km. It is a little bit bigger than Taiwan which has an area about 36,000 square km. But the Dutch population is about 16 million people and owns 19 million bicycles. Moreover, and the total bikeways length in the Netherlands is more than 17,000 kilometers compared to Taiwan's 700 kilometers of bikeway.

Copenhagen, the capital of Denmark, has a population of about 1.8 million people. Approximately one-third use bicycles to commute to work and only one-quarter drive to work. Ninety percent of Copenhageners own a bicycle. Those who do not use their bike to commute to work use it for exercise or to run errands (Rollman, n.d.). Replogle (1995) pointed out that road building was abandoned in the early 1970s. A large numbers of bus priority lanes were introduced, and a comprehensive network of segregated cycle paths were built. The result was a ten percent decrease in traffic since 1970 and an 80% increase in the use of bicycles since 1980. About one-third of commuters now use cars, one-third use public transport, and one-third use bicycles. Cycling accidents have decreased slightly, despite the increase in mileage, because of the network of cycle paths, which in many cases were created by reallocating arterial street space from cars.

Tokyo, Japan is a good example of cycling nation. About 7.1% of the total urban areas is used for roadways and a city metro network of 614 km in length. The ownership of motor vehicles is 234 per 1,000 people. Despite such high motorization, bicycle mode shares 36.1% of the total trips made in the Tokyo areas. This percentage is still rising. The Bicycle Law issued and implemented by the Japanese government in 1980 encourages the local governments to provide bicycle lanes and bicycle parking facilities near the metro stations. Japan has concluded that the bicycle is an essential component of the passenger transportation system. As a complementary tool, bicycles function "feeding" the passengers into the public transportation system.

Many commuters actively commuted to work because the distance was "short" and the public transport service and infrastructure was "poor" (Oja, Vuori & Paronen, 1998). Active commuters were also motivated by a desire for fresh air and to improve their overall health and fitness (Oja et al., 1998; Crawford, Mutrie & Hanlon, 2001).

China, the kingdom of bicycles

Liu et al. (2003) claimed that China has the largest number of bicycles. Currently about 500 millions bicycles are registered in total. This represents an average rate of 400 vehicles per thousand people. Meanwhile, the number of bicycles used in cities accounted for 200 millions. From the standpoint of bicycle possession and use, China is no doubt ranked on the top over all other countries in the world. It has been known as the “Kingdom of Bicycles”. The three factors that made China the “Kingdom of bicycles:” include the following: historical reasons, economic reasons, and dense land use.

In the early 1980s as the “Open Policy” was lunched, Chinese economic reform was in the exploratory phase. As a low-cost transport tool, bicycles were affordable for most families, and of course, most city inhabitants owned bicycles. The average personal income had increased significantly compared to that of the 1980s. Some inhabitants became capable of owning a motorcycle or a private car. As a result, some bicycle trips were diverted into motor vehicle modes, especially with the entry of China into the World Trade Organization (WTO) in 2001 (Liu et al., 2003). The Chinese government saw the problem and currently adopted the policy that encouraged the development of the automobile industry as a cornerstone of the Chinese economy.

The existence of the bicycle is determined by the inhabitant’s travel habits and income level. Bicycle trips in cities have existed extensively for decades, and also have a long effect on the planning and construction of urban transportation infrastructures. Moreover, privately owned cars are still a luxury product for a common Chinese family even though the average personal income has increased enormously (Liu et al., 2003).

Different types of cyclists use different facilities

Rivera (2003) concluded that his suggestion for a better cycling commuting situation are: first, recognizing that the bicycle is an important alternative mode of transport, second, constructing a cycle network is required and so are parking facilities, third, improving more traffic and social safety for bicycle users must be ensured, fourth, understanding that these facilities are easier to implement on flat areas, fifth, understanding that the most adequate age for the use of the bicycle is between five and 35 years of age, and sixth, understanding that the most motivated users of the bicycle are students and workers.

In foreign countries, different groups of cyclists have different road preferences.

Table 15. *Classification of Rider Types.*

Type	Description	What they prefer
A-Advanced Bicyclist	Can operate under most traffic conditions	Efficiency, maximum speed, few delays, ease of passing, sufficient shoulder area
B-Basic Bicyclist	New adult riders, teen-age riders	Direct routes, low speed, low traffic volume, well-defined or separate routes.
C-Children	Children, usually monitored	Adjacency to schools, parks, low speed, well-defined routes

Source: A Virginia Guide for Bicycle Facility Planning, 1994

The Netherlands has the highest percentage of bicycle trips, 27%; followed by the Denmark with 20%. The Netherlands and Denmark are the two countries that are famous for bicycle commuting and bikeway systems.

Table 16. *Transportation mode split in percent of total trips.* Unit: %

Urban Area	Car	Public Transit	Bicycle	Walk	Other
Austria	39	13	9	31	8
Canada	74	14	1	10	1
Denmark	42	14	20	21	3
Netherlands	44	8	27	19	2
Sweden	36	11	10	39	4

Switzerland	38	20	10	29	3
United Kingdom	62	14	8	12	4
U.S.	84	3	1	9	3

Source: Litman, 1999

Bicycle trips in different countries have different distribution, with the Netherlands having the highest percentage of bicycle commuting. They had 24% in 1998 compared to two percent of bicycle usage in Taiwan.

Table 17. *Purpose of Bicycle Trips in the Netherlands, Germany, and the USA*

(Percentage distribution of trips by trip purpose). Unit: %

Bicycle Trip Purpose	USA (1995)	The Netherlands (1998)	Germany (1995)
Working Commuting	9.0	24	20
Shopping	12.7	19	26
Social or Recreational	69.5	40	36
School	8.8	17	15

Source: Pucher & Dijkstra (2000)

Global Bicycling commuting conditions

It is a challenge to find out the entire bicycle commuting percentage in each country. To some extent, the problem is that there is a lack of bicycle commuting studies. The researcher made an effort to acquire all the data, Moritz (1997) found that there are 0.3 percent of bicycle commuters in North America, Pucher and Rene (2004) found out 0.4 percent of bicycle commuters were in the United States, and Pucher and Buehler (2005) found out 1.2 percent of bicycle commuters were in Canada and currently only two percent of the journeys in Britain above one mile are business (41%) or leisure (31%) (Nottinghamshire County Council, 2000).

In America, the national average of cycling commuting is less than one percent, however; the City of Davis is known as “The Bicycle Capital of the U.S.” estimated to have almost one-quarter of all trips made by bicycles. Bustos (2006) reported that Davis is blessed with a mild climate, low yearly rainfall, and a flat topography that make bicycling a legitimate mode of transportation. Second, as the home of the University of California at Davis, the city has a large population of healthy, young students with limited incomes for whom bicycles provide a cheap and convenient form of transportation. Furthermore, the university is located at the center of a one square mile city limits, thus providing a centrally located destination. The city itself is surrounded by agricultural fields that separate the city for miles from the nearest towns and cities. These factors make it possible for nearly every student and staff member and faculty members to live within a one to three mile radius of the University.

It is not all about the climate

Non-motorized vehicles are severely affected by bad weather, such as rain, snow or extremely hot days (Porter, Suhrbier & Schwartz, 1999). To some extent, bad weather condition in countries could play a factor in a deficient bicycling population. However, there was an interesting finding by Pucher and Buehler (2005). He stated that in spite of their colder climate, Canadians cycle about three times more than Americans. The main reasons for these differences are: Canada’s higher urban densities and mixed-use development, short trip distances, lower incomes, higher costs of owning, driving and parking a car, safer bicycling conditions, and more extensive bicycling infrastructure and training program. Pucher and Buehler (2005) concluded that it seems likely that differences in transport and land use policies play an important role in explaining the higher share of bike trips in Canada.

Furthermore, the greater availability of transit services in Canada may complement bike use by serving those trips too long to cycle, thus facilitating a less car-dependent lifestyle.

Besides, studies have shown that climate conditions have little effect on cycling habits. In the two extreme conditions of cold and wet Amsterdam and hot and dry New Mexico, bicycle programs have proven to be a great success (Nankervis, 1999).

According to Taiwan Central Weather Bureau (CWB) (2007) and Wikipedia (2007), rain can be divided into:

Table 18. *Classification of rain type.*

	Central Weather Bureau	Wikipedia
Very light rain	None	when the amount of precipitation is < 250 mm (< 250 liter/m²)
Light rain	None	when the amount of precipitation is between 250 mm - 750 mm (250 liter/m² - 750 liter/m²)
Moderate Rain	None	When the amount of precipitation is between 750 mm - 1500 mm (750 liter/m² - 1500 liter/m²)
Heavy rain	When the amount of precipitation is > 50 mm in past 24 hours, and at least one of 24 hours' precipitation is > 15 mm	When the amount of precipitation is between 1500 mm - 2000 mm (1500 liter/m² - 2000 liter/m²)
Very heavy rain	None	When the amount of precipitation is > 2000 mm (> 2000 liter/m²)
Extremely heavy rain	When the amount of precipitation is > 130 mm in past 24 hours	None
Torrential rain	When the amount of precipitation is > 200 mm in past 24 hours	None
Extremely torrential rain	When the amount of precipitation is > 350 mm in past 24 hours	None

Source: CWB (2004) and Wikipedia (2007), organized by the researcher

The northern part of Taiwan such as Taipei has more precipitation than the central and the southern Taiwan; however, the average temperature of southern part of Taiwan such as Kaohsiung is higher than the northern and the central Taiwan. Below is a critical criteria of Taiwan meteorology table, it shows the average temperature and precipitation in different areas in Taiwan.

Table 19. *Critical criteria of Taiwan meteorology.*

Time	Taipei		Taichung		Kaohsiung		Hualien	
	Average temperature	Precipitation	Average temperature	Precipitation	Average temperature	Precipitation	Average temperature	Precipitation
	℃	millimeter	℃	millimeter	℃	millimeter	℃	millimeter
1999	23.0	1,958.1	23.7	1,390.4	25.2	2,763.6	23.6	1,677.0
2000	23.2	2,744.0	23.7	1,797.0	25.1	1,569.0	23.7	2,460.5
2001	23.3	2,862.1	23.6	1,981.2	25.1	2,556.5	23.7	2,568.5
2002	23.8	1,346.4	24.1	1,315.6	25.6	1,037.5	23.9	1,062.3
2003	23.5	1,192.5	23.9	930.6	25.4	1,326.0	23.6	1,348.5
2004	23.1	2,829.8	23.4	2,260.7	25.2	1,439.5	23.3	1,983.0
2005	23.3	3,027.8	23.3	2,574.5	25.0	2,821.4	23.4	2,777,0
2006	23.8	2,288.4	23.8	2,171.9	25.7	2,045.5	23.7	1,901.0
Mar	18.7	162.2	19.7	93.4	22.7	11.0	19.9	116.0
Apr.	23.1	289.5	24.1	221.6	26.3	92.5	23.2	84.5
May.	25.5	316.6	26.1	316.3	28.2	107.0	25.3	310.5
Jun.	28.0	391.0	27.1	754.5	28.6	568.5	26.4	235.5
July	30.3	185.5	28.8	328.9	29.0	901.5	28.3	214.5
Aug.	29.9	127.8	28.8	117.4	29.1	159.0	28.0	314.0
Sept.	27.0	367.5	27.2	143.7	27.9	161.0	26.4	272.0
Oct.	25.6	36.7	25.9	--	27.4	1.5	25.4	99.0
Nov.	22.9	140.7	23.2	95.7	25.5	36.0	22.9	89.5
Dec.	18.8	141.2	18.9	49.2	21.4	2.0	20.0	5.0
2007	18.6	444.4	19.1	169.4	21.8	23.0	19.8	112.0
Jan.	17.3	111.4	17.2	57.0	19.7	8.0	18.5	55.0
Feb.	18.7	70.5	19.3	24.5	22.1	7.5	20.2	9.0
Mar.	19.7	262.5	20.7	87.9	23.5	7.5	20.8	48.0

Source: CWB (2007)

The percentage of walking for these three countries from 1978 to 1995 has slightly decreased. On the other hand, the percentage of bicycling has slightly increased.

Table 20. *Trends in Walking and Bicycling Share of Travel in the Netherlands, Germany, and the United States, 1977-1995 (As percentage of all trips by all modes).*

Country	Year					
	1978	1983	1987	1990	1992	1995
			Walking			
Netherlands	18	19	19	17.4	17.1	17.1
Germany	34	30	26	No data	23	22
USA	9	9	No data	7	No data	6
			Bicycling			
Netherlands	26	29	26.5	28.5	27.1	27.3
Germany	7	10	12	N/A	12	12
USA	0.6	0.8	No data	0.7	No data	0.9

Source: Pucher and Dijkstra (2000)

The bikeway development in Taiwan is different from bikeway development in foreign countries.

Table 21. *Comparison of Bicycle Tourism Development in Taiwan and Overseas.*

Comparing Items	Development in Taiwan	Overseas Development
Origin of bicycle tourism	Government's grant and plan	Public spontaneous demand
Bicycle users	Minor users: most are from fixed groups or associations	Many participators; frequent use of bikes
General understanding of bike lane	Bicycles should not ride on roads	Privilege for cyclists
Construction of bike lanes	Segregation of special bicycle lanes from major traffic	Integration of bicycle lanes into the existing environment
Placement location	Scenic areas, amusement areas, country towns and riverside areas	Scenic areas, amusement areas, country towns and urban areas
Development review	Cannot fit into users' real demand; lack of services, facilities, maintenance and management	Satisfying users' demand and sound services and facilities.
Development position	Preliminary stage of tourist development	Tools for commuting to schools

		and recreation
Development goals	Sport Development	Sustainable development of green transportation mode and green products.

Source: Chang & Chang (2003)

Summary

Four decades ago, Taiwan was a country filled with bicycles. We built them and we rode them. The bicycle had a historical impact on Taiwan; however, with the rise of the Taiwanese GDP, more and more people could afford to buy a motorized vehicle, thus turning the bicycle from a tool into a toy. Japan is a developed country and is crowded like Taiwan, with a high motorized vehicle ownership. However 36.1% of their trips are made by bicycle. Japan's commuting situation is similar to Taiwan's. We should learn our lessons from Japan.

According to the data of this research, climate is the major constraint that affects recreational cyclists to bicycle as a form of commuting. The climate factors include: typhoons, heavy rain, as well as hot and cold temperatures. However, Pucher and Bhehler (2005) discovered that although Canada is colder than America, and that the climate situation in Canada is worse than in America, Canadian bicycle trips are three times more than in American. They concluded that the major reason is bicycle policy. They believe a well-developed bicycle policy could overcome climate constraints. Although the weather in Taiwan is highly changeable, the government and related offices should draw up bicycle policies and set up bicycle facilities which will encourage the population to use bicycles as a means of commuting.

The Reasons That Taiwanese Do Not Cycle

Taiwanese do not cycle as much as those in some European countries because of the following six points:

1. Bicycle ownership is inadequate: There are 23 million residents in Taiwan; however, only 1.1 million own bicycles. The average Taiwanese has only 0.05 bicycles, compared to an average resident in the Netherlands having 1.6 bicycles. An inadequate number of bicycles is a structural constraint that is involved in bicycling. Crawford, Jackson and Godbey (1991) concluded that structural constraint is the most direct constraint.

2. Climate: Porter et al. (1999), and Allen, Rouphail, Hummer and Milazzo II (1998) found that the use of non-motorized vehicles are severely affected by the climate. The climate in Taiwan is hot and humid, and the riders sweat a lot while bicycling. Nankervis (1999) concluded that heavy rain is the most powerful deterrent for bicycling. The most common conclusion has been that recreational cycling is affected by variations in weather more than commuting by bicycle. The analysis above has produced a strong relationship between current weather conditions and both recreational bicycling and commuting by bicycling.

3. Insufficient bikeways: Bikeways in Taiwan are not prevalent compared to more than 17,000 km of bikeways in the Netherlands; Taiwan only has about 700 km of recreational bikeways.

4. Safety: The percentage of motorcycle ownership in Taiwan is the highest in the world. Hence, cyclists are at risk while using roadways crammed with motorcycles (Hou, 2005, Demaio & Gifford, 2004). From a psychological perspective, heavy traffic conditions cause anxiety and stress. Worried parents prevent their children from cycling on their own (Hillman, 1990). Besides, Krizek, Johnson and Tilahun (2004) remarked that bicycling is well recognized as being the riskiest mode of transportation, and Aultman-Hall and Hall (1998) wrote that bicycle accident rates are ten times higher than rates for automobile travel. Watchel (1994) reported that in 1992, 722 bicyclists were killed in the United States in collisions with motor vehicles, and an estimated 650,000 people were treated in emergency room for bicycle-related injuries. Hunter, Harkley, Stewart and Birk (2003) further pointed out that intersections and intersection-related locations account for 50-70 percent of bicycle-motor vehicle crashes in the United States.

5. Bicycle theft problem: Compared with other motorized vehicles, bicycles are light and have no identification tags on them; thus, bicycles are easily stolen by thieves (Tsao & Lin, 2004; Forester, 2005). Moreover, Taiwan lacks bicycle lockers, or secure parking areas (Chen, 1999). Thus, it even makes it easier for thieves to steal bicycles. The Australian standards define “secure”, as having both wheels and the frame locked to the facilities (Austroads, 1999; Herman, 1993, however, t is difficult to see any “secure” bicycle parking facilities in Taiwan. According to the European Cyclists’ Federation. (1991), the fear of bicycle theft is one of the reasons why people do not own a bicycle or do not use the bicycles as often as they would like.

6. Air pollution: Chen (1999) found air pollution is one of the critical influences of cyclists to commute or not. Most of the Taiwanese are afraid that bicycling in air-polluted conditions may endanger their health.

In Pittsburgh, local cyclists cited the following factors as major impediments to cycling in Pittsburgh. They are topography, bridge crossings, climate, narrow streets, high levels of road user conflict, roadway surface hazards, insensitivity of local agencies to the needs of cyclists, inadequacies of existing bike routes, scarcity of bicycle parking, lack of bicycle commuter facilities, a need for greater transit access, a lack of off- road mountain biking facilities (City of Pittsburgh Bicycle Plan, n.d.).

Summary

The six reasons above are why Taiwan's citizens do not cycle as much as Europeans. The second reason is the climate. That is a natural factor that cannot be solve, while the other four reasons could be solved by the Taiwanese government and its citizens. Insufficient bikeways, safety, and bicycle theft problems could be solved by improving bicycle facilities, such as bikeways and bicycle parking areas.

Bicycle Policy Development in Taiwan and Foreign Countries

Taiwan is increasing its investments in bicycle tourism. Both the central and local governments have been trying to stimulate the development of bicycle tourism and recreational bicycling (Chang & Chang, 2005), however; Huang, Shiue and Lin (1999) and Hou (2005) have indicated that the Taiwanese government has neglected the benefits of bicycling and paid little attention to bicycle facilities.

Wang (2005) observed that bikeways in Taiwan are not prevalent, especially the commuting bikeways. Most of the bicycle commuters are students. This lack of commuting bikeways makes students exposed to dangerous bicycle commuting conditions. Wang (n.d.) also claimed that the most attractive policy of students cycling to school is the policy of "Adding the pathways and bicycle lanes". Furthermore, Pucher, Komanoff and Schimek (1999) agreed that bikeways can be a powerful way to encourage non-cyclists or occasional riders to cycle as a form of regular transport.

There are many methods which can reduce the problems of bicycle commuting. Aultman-Hall, Hall and Baetz (1997) wrote that reasonable efforts might include providing wider curb lanes, actuated traffic signal detectors that recognize the presence of bicycles, or the installation of signals along heavily used bicycle corridors at locations where turns or major street crossings are required. A project to build off-road paths or trails should be either recognized as primarily for recreation or designed to be direct and convenient. Besides, Waerden, Borgers, and Timmermans (2003) suggested that planners should focus on improving the pavement, extension of bicycle paths, and bicycle priority at crossings.

The Netherlands has a strong bicycle policy aimed at stimulating bicycle usage and increasing the cyclist's safety (CROW, 1993). The policy has five spearheads including the improvement of bicycle infrastructures; the creation of good connections with public transport; fostering of road safety; prevention of bicycle theft; and promotion of bicycle usage. Measures to discourage and curb car use are seen as important to the success of the cycling policy. Land-use policies that create a compact urban form with mixed-use are also essential to the stimulation of bicycle usage. Strong bicycle policies together with measures to discourage auto use, amidst compact, and mixed-use urban forms have stimulated high levels of bicycle usage in the Netherlands.

The bicycle facilities could be improved by AASHTO's Guide (2001)

Table 22. *Roadway Improvements for Bicycle Facilities.*

Roadway Improvement	Description
Drainage Gates	Drainage gates/utility covers should be flush with the roadway and clearly marked
Railroad Crossings	Crossings should be at a right angle to railway with a consistent elevation and warning signs
Pavements	Consistent pavement is desired, the edge of the pavement should be at a constant width
Traffic Control Devices	Traffic lights should allow ample clearance time for cyclists, a good gauge is a 10 mph speed with 2.5 second braking/reaction time
Shoulders	Minimum shoulder width of 4 feet for bicycle travel, smooth consistent pavement
Wide Curb Lanes	Ideal lane width for car and bicycle use is 12 to 14 feet, allows ample space for both

Source: The AASHTO Guide, 1991

In 2002, Taiwan's Sports Council launched the Planning and Establishment of Bikeway System in Taiwan. Such a program is aimed to encourage the development of local green industries through elevating tourism and transportation development. Approximately 2.1 billion NT dollars have been invested on such a development.

Good parking facilities not only reduce the risk of theft, they can also increase the importance and status of the bicycle, which in turn will stimulate cycling (Guit, 1993). Bicycle parking facilities should be located close to the destination. Well located parking facilities will be appreciated, badly located ones will never be used (European Cyclists' Federation, 1991). Good parking facilities located close to the destination can add to the attractiveness of the bicycle as a faster means of transportation with few parking problems (Guit, 1993).

Liu et al. (2003) claimed that the characteristics of bicycle transport for a travel distance 0.5 km to three km are the most preferential to the use of the bicycle. Trips for more than three km distances should be carried out by public transport. First of all, bicycle parking facilities must be built up at large public transit stations and at many stops as possible. This is the basic prerequisite to implement the "Bike-and-Ride" strategy.

Bikeways help cyclists to recognize, and reduce the fear of same-direction motor traffic. Therefore, it is believed the provision of bikeways will cause a significant switch from motorized transportation to bicycle transportation (Forester, 2005). The bicycle infrastructures should be comfortable. The comfort of the cyclist is affected by a number of factors including the quality of the road surface, wind, gradients and the necessity to slow down and accelerate (Goodefrooij and Pettinga, 1993).

Summary

Reducing air pollution, fuel-saving, and improved fitness level are what bicycle commuting can bring to us. It is obvious that bicycle commuting has many advantages; however, "Is Taiwan suited for bicycle commuting?" and "Is it worthwhile to build bicycle facilities in Taiwan?" are questions that need to be answered. These are controversial issues for all bicycle commuters. The other issue is, “If government builds bicycle facilities, will they attract more bicycle commuters to use the facilities?” or will they cause another traffic problem if they are not used at all?

The Netherlands and Denmark could be described as the paradise of bicycle commuters; however, three decades ago, these two countries suffered the same traffic problems as seen in Taiwan today. Roadways were congested with motorized vehicles and they were not countries suitable for bicycle commuting. However, since the bicycle policies were introduced in the Netherlands and Denmark, bicycle commuting has grown in popularity. It is definitely a hard work to educate people, and bicycle policy implementation may take a long period to be accomplished. It is a long way and rough road, from constructing bicycle facilities to educating the people. Although it is a long and rough journey, it is the road that we should take.

Most of the Taiwanese’ commuter mileage is below five km. The average cycling speed is 20 km per hour. Five km of commuting route could be finished within 15 minutes. Bicycle commuting does not take too much time. However, Taiwan lacks commuting bikeways, thus, it is a challenge to ride through intersections, and both air pollution and the climate can all affect people to choose cycling as a mode of commuting. The Taiwanese government should devise measures to counter the bicycle commuting constraints, and encourage more people to use bicycle commuting as a mode of transportation.

Research Hypotheses

Hypotheses were proposed after a review of the literature and problem analysis.

(1). In general, recreational cyclists would not use bicycles for commuting.

(2). Two reasons for the low numbers of bicycle commuters in Taiwan compared to European nations are the lack of well developed bicycling policies and lack of bicycle facilities..

(3). Recreational cyclists choose bicycle commuting because of the fitness concern.

(4). More recreational cyclists could be encouraged to use bicycle as a means to commute with appropriate bicycle policies and sufficient bicycle facilities.

Chapter 3

METHOD

Research Design

According to the purposes of the study and review of the literature, this research aimed to discover the relationship between recreational bicyclists and bicycle commuting. Therefore, the researcher investigated the relationship between recreational bicyclists' demographic data and bicycle commuting, discovered the motivations for bicycle commuting, and finally found out the constraints for bicycle commuting.

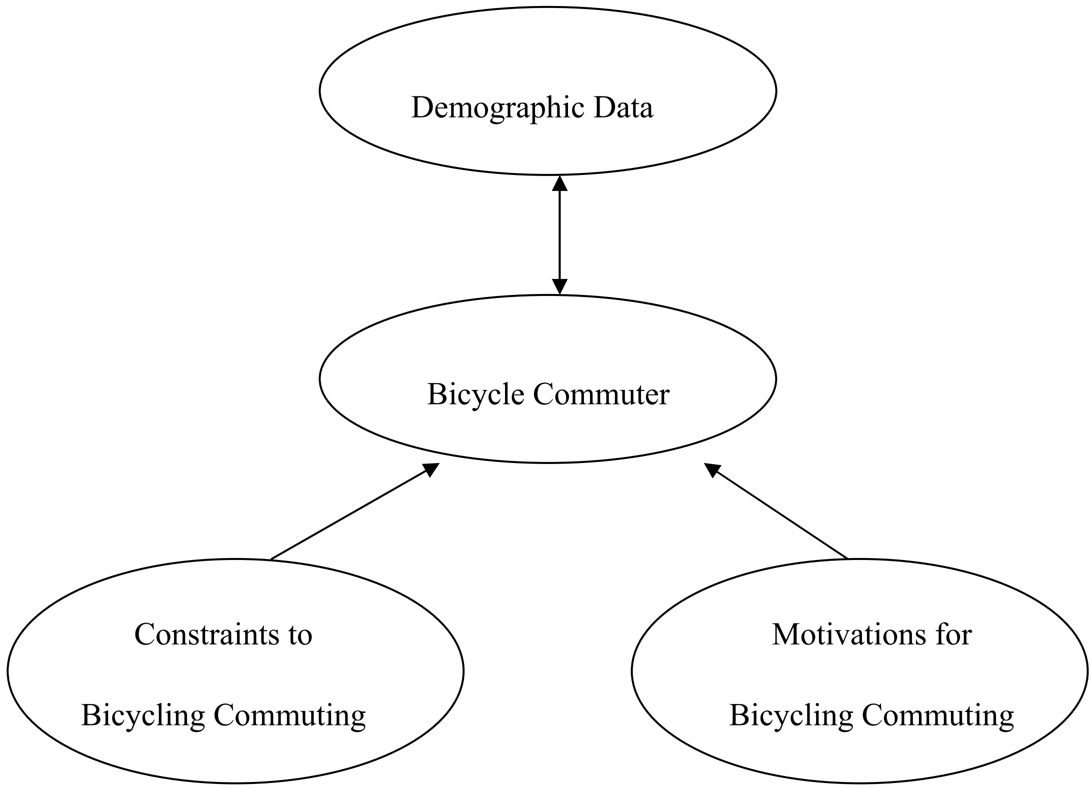


Figure 4. Research framework.

Research Scope

K. H. Chang (2004) framed that the study of bicycling into seven issues. They are: leisure, tourism, recreation, transportation, commuting to school and commuting to work. This research focused on transportation, commuting to school and commuting to work.

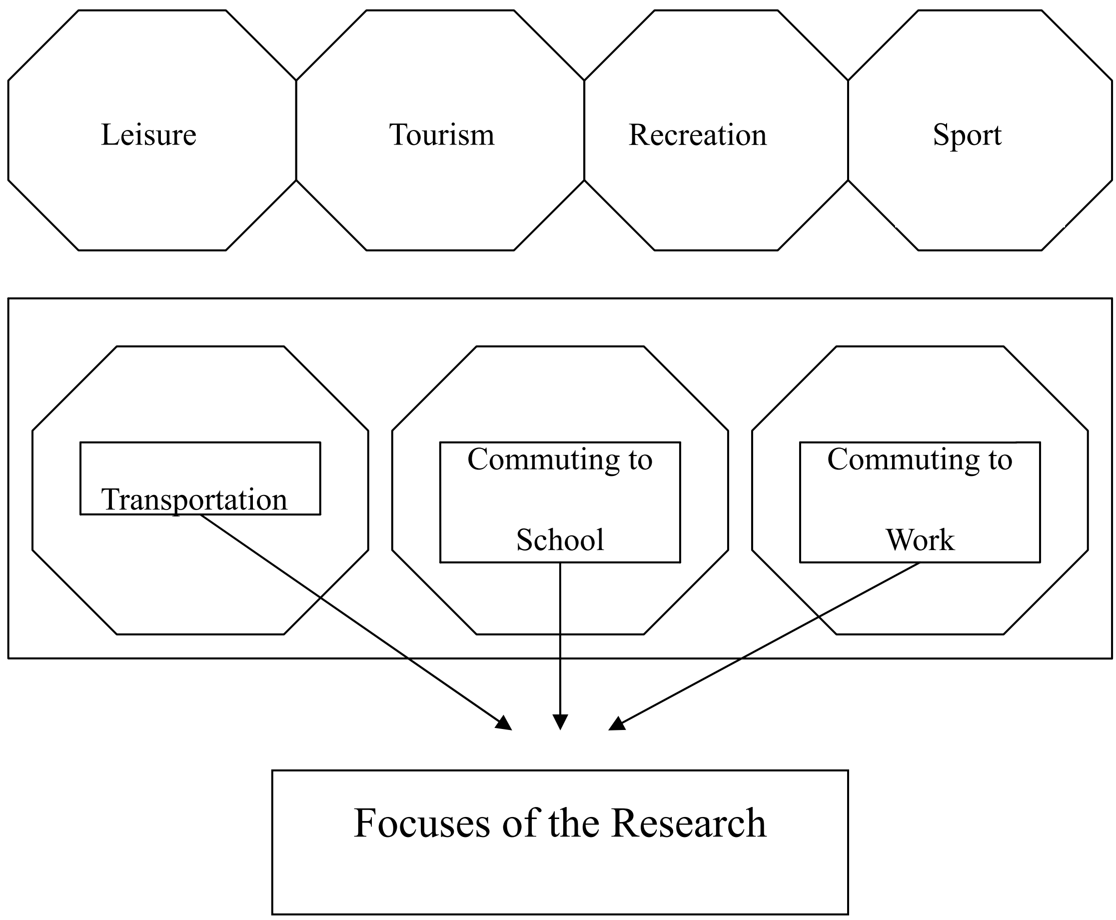


Figure 5. Focuses of the research.

Sampling

A random sample of bicycle commuters was the desired research method for this study. The problem was locating such commuters across the country. In contrast to motorist and automobiles, which must be licensed, there is no practical way to identify people who own bicycles, let alone those who might use them for commuting (Moritz, 1997). Therefore, convenience sampling was adopted in this study.

The locations to distribute the questionnaires included the following: bicycle activity events, bicycle competitions, and bicycles shops. A total of 440 questionnaires were distributed to recreational cyclists. Only 392 questionnaires were valid, and 48 questionnaires became invalid. The response rate was 89.2%. 315 questionnaires were given to males and 77 questionnaires were given to females. The data about the location and the participants are shown in Table 23.

Table 23. *Recreational cyclists' population of the study.*

Number	Location	Population		Date
		Male	Female	
1	Bicycle and Life Magazine staff in Taichung	3	1	2007/3/20
2	Timobike bicycle club in Taichung	13	0	2007/3/21
3	Fifth Stage of Tour de Taiwan in Taichung	15	13	2007/3/22
4	Taipei International Cycle Show at Taiwan World Trade Center (TWTC)	39	13	2007/3/24 to 3/27
5	North Coast Bicycle Competition, first stage of Taiwan Cycling Club Series Year 2007	83 (rain)	11 (rain)	2007/3/25
6	Xin-xin Bicycle Shop in Taichung	17	1	2007/3/29
7	Ba-gua Mt. in Chang-hua County	38	8	2007/3/31
8	Delan Bicycle activity in Nan-tou County	59	7	2007/4/1
9	2007 Taichung County's Bicycles and Horses Tourist Festival bicycle activity at Ho-feng bikeway	48	23	2007/4/15
	Sum	315	77	
	Total	392		

Instrument

The researcher designed a questionnaire based on one by Moritz (1997) which was modified by the researcher. The information was divided into five categories: about your household; about the commuting; about your facilities; about your commuting expenses and about stolen bicycle experiences. A comment space was provided at the end of the survey.

(1) About you and your household

A series of questions were asked regarding gender and the number of automobiles owned.

(2). About your commuting

The interest here was to learn how many years the respondents had been commuting by bicycle if that was the case, and why bicycle commuting was not their primary commuting mode if the respondent was not a bicycle commuter.

(3). About your facilities

Two multiple questions attempted to assess the following: first, "What facilities you can use at your commuting destination?" second, "In what way did your company or how did your school encourage you to use cycling as a form of commuting?" and finally which was followed by a single question, "What is your most desired bicycle facility at a commuting destination?"

(4). About your commuting expenses

These questions inquired about the commuting expenses for recreational cyclists. This was divided into three parts: a car, a motorcycle, and mass transportation.

(5). About your stolen bicycle experience

Two questions here asked whether the recreational cyclists had any experiences with their bicycle being stolen or not. If yes, did they call the police when or while their bicycle was being stolen?

A space for comments was provided for any additional information the respondent wished to provide.

Content validity

Upon drawing up the questionnaire, the researcher had requested expert help from his professor and other sources of professional helps to revise the questionnaire and give favorable suggestions. The cycling expert including the Bicycle and Life magazine editor in chief Greg Chang, reporter editor Lisa Huang, art editor Jimmy Peng, Jacky Tseng, Giant Hua-shan bicycle shop owner Timolthy Lai, and Xin-xin bicycle shop owner. The professors included Ding-shyong Chen and Rui-mei Yu from National Taiwan College of Physical Education. From these experts' and professors' suggestions, the researcher had modified the questionnaires.

Added the following items help to motivate and encourage the public to bicycle as a means of commuting: first, enjoying riding a bicycle, second, commuting distance was short, third, without motorized vehicle, fourth, recommended by family or relatives.

Added the following items to constraint the public from bicycle commuting: first, no bike can meet my commuting needs, second, bad pavement, third, the bicycle is undependable (e.g. Flat tire, and falling chain).

Questionnaires implementation

The researcher had contacted with bicycle club's leaders or bicycle's shop owners before the questionnaires were distributed, and confirmed how many club members they had in each club. The researcher distributed the questionnaires in person and informed the participants how to answer the questions, and was notified in this academic research questionnaire; the data was used for nothing but research analysis. If the club members could not come to answer the questionnaires, the researcher asked for bicycle shops' owners or bicycle clubs' leaders to help to distribute the questionnaires to their members; the researcher informed them of the purpose of the study and that the matter needed attention to achieve standardization of questionnaire implementation.

Data Analysis

After receiving the returned questionnaires, coding and keying in the data of each participant was implemented. Then, SPSS 12.0 English version was used for data analysis, descriptive statistics analysis, and Chi-square test were all used in data processing.

1. Frequency distribution of demographic data and bicycle commuting data of the participant.
2. Chi-square test.

Chi-square is a non-parametric test of statistical significance for bivariate tabular analysis. Any appropriately performed test of statistical significance lets you know the degree of confidence you can have in accepting or rejecting a hypothesis. An alpha level of .05 was used for all statistical tests.

Chapter 4

RESULTS

Descriptive Analysis

A total of 450 questionnaires were distributed to recreational cyclists. There were 392 were questionnaires in return. However 48 questionnaires were voided because they were incomplete. The effective response rate was 89.2%.

Demographic data analysis

The demographic data of the subject have nine items. They are gender, age, occupation, car ownership, motorcycle ownership, bicycle ownership, marital status, usual commute mode, and commute distance.

(1). Gender

Males accounted for the majority of the sample with 315 in total or 80.4% of the sample. This showed that males accounted for the majority of recreational bicycling; females accounted for only 77 of the total or 19.6% of the sample (See Table 24).

Males comprise the majority of recreational bicycling participants, and the possible reasons that less female participate in recreational bicycling are because of the following reasons: first, fear of sun exposure affecting their complexion, second, worries of legs becoming muscular, and third, riding safety. These results are similar to Krizek, Johnson and Tilahun's (2004), and Liao's (2003) study.

Table 24. *Gender of the study participants.*

Variable		Frequency	Percent (%)
Gender	Male	315	80.4
	Female	77	19.6
	Total	392	100.0

(2). Age

The 26 to 35 years old group accounted for the majority of the sample with 132 people or 33.7% of the sample (See Table 25).

Age could be a criterion of fitness level and recreational activity participation; most recreational cyclists were younger than 45 years old accounting for 86.5%. Recreational bicycling can be both highly intensive and low intensive exercises. In this study, the questionnaires distribution locations were at highly intensive bicycle activities and competitions. Thus, the elderly account for fewer samples. This result was similar to Lo and Lin's (2006) study.

Table 25. *Age of the study participants.*

Variable		Frequency	Percent
Age	<15 yrs	13	3.3
	16-25 yrs	100	25.5
	26-35 yrs	132	33.7
	36-45 yrs	94	24.0
	46-55 yrs	45	11.5
	56-65 yrs	8	2.0
	>66 yrs	0	0
	Total	392	100.0

(3). Occupation

Laborers accounted for the majority of the sample with 107 people or 27.3% of the sample (See Table 26).

Students and laborers accounted for 53.6% of the sample; the researcher supposed that physical active occupations have a higher chance to be recreational cyclists such as laborers and students. This result is corresponded with Rivera's (2003) study; he claimed that the most motivated users of the bicycle are students and workers.

Table 26. *Occupation of the study participants.*

Variable		Frequency	Percent
Occupation	Student	103	26.3
	Military, Civil, and Teaching Personnel	17	4.3
	Service Industry	60	15.3
	Homemaker	6	1.5
	Laborer	107	27.3
	Businessman	54	13.8
	Freelancer	29	7.4
	Agricultural, Forestry, Fishery, and Husbandry	3	0.8
	Other	13	3.3
	Total	392	100.0

(4). Car ownership

One-car ownership accounted for the majority of the sample with 206 people or 52.6% of the sample; the mean was 0.76 cars per recreational cyclist, standard deviation was 0.701 (See Table 27).

There were 63.3% of recreational cyclists who has at least one car(s). Recreational bicyclists and bicycle commuters have one thing in common, they ride bicycles; however, recreational bicyclists view bicycles as toys, and they still needed a car to transport their bicycles to ideal destinations; bicycle commuters took bicycles as a means of transport, and they can ride bicycles directly to their schools or offices. This results in recreational cyclists having a higher percentage in car ownership.

Table 27. *Car ownership of the study participants.*

Variable		Frequency	Percent (%)	Mean	Std. Deviation
Car(s)	0	144	36.7		
	1	207	52.8		
	2	36	9.2		
	3	2	0.5		
	4	3	0.8		
	Total	392	100.0	.76	0.701

(5). Motorcycle ownership

One-motorcycle ownership accounted for the majority of the sample with 234 people or 59.7% of the sample; the mean was 0.85 motorcycles per recreational cyclist, the standard deviation was 0.676. (See Table 28).

There were 71.1% of recreational cyclists who had at least one motorcycle(s). Recreational bicyclists take bicycling as leisure; they ride for fun in their leisure time. On the weekdays, they still need motorcycles to transport themselves to schools or offices. This made recreational cyclists have a higher percentage in motorcycle ownership.

Table 28. *Motorcycle ownership of the study participants.*

Variable		Frequency	Percent (%)	Mean	Std. Deviation
Motorcycle(s)	0	113	28.8		
	1	235	59.9		
	2	37	9.4		
	3	5	1.3		
	4	2	0.5		
	Total	392	100.0	.85	0.676

(6). Bicycle ownership

One-bicycle ownership accounted for the majority of the sample with 151 people or 38.5% of the sample; the mean was 1.86 bicycles per recreational cyclists, the standard deviation was 1.684 (See Table 29).

There were 86.5% of recreational cyclists who had at least one bicycle(s); still 13.5% of them did not own any. The reasons that the recreational cyclists do not have bicycles may because that they rent bicycles at bicycle rental shops or borrowed from their friends.

Table 29. *Bicycle ownership of the study participants.*

Variable		Frequency	Percent (%)	Mean	Std. Deviation
Bicycle(s)	0	53	13.5		
	1	151	38.5		
	2	95	24.2		
	3	45	11.5		
	4	26	6.6		
	5	9	2.3		
	6	4	1.0		
	7	2	0.5		
	8	2	0.5		
	10	4	1.0		
	11	1	0.3		
	Total	392	100.0	1.86	1.684

(7). Marital status

Unmarried people accounted for the majority of the sample with 194 people or 49.5% of the sample (See Table 30).

Single people have more leisure time than those who are married; thus single people accounted the majority of recreational cyclists. Liao’s (2003) study found that those who were married had less chance for recreational bicycling because they needed to take care of their children.

Table 30. *Marital status of the study participants.*

Variable		Frequency	Percent
Marital status	Unmarried	194	49.5
	Married (no kids)	37	9.4
	Married (kids under or in elementary school)	75	19.1
	Married (kids above or in junior high school)	86	21.9
	Total	392	100.0

(8). Usual commute mode

Riding a motorcycle accounted for the majority of the sample with 131 people or 33.4% of the sample (See Table 31).

There were only 2.6% of recreational cyclists who used mass transit to commute; it shows that the mass transit system probably could not meet citizens' needs. There were 66.4% of recreational cyclists who used motorized vehicles as their commute mode, despite the majority of commuting distances being shorter than five km. The reasons may because that people who stigmatized the bicycle as an undeveloped commute tool; therefore, motorized vehicles were a status symbol to them.

Table 31. *Usual commute mode of the study participants.*

Variable		Frequency	Percent
Usual commute mode	Car	130	33.2
	Motorcycle	131	33.4
	Bicycle	111	28.3
	Walk	10	2.6
	Transit	10	2.6
	Total	392	100.0

(9). Commute distance

Commute distances of less than five km accounted for the majority of the sample with 156 people or 39.8% of the sample (See Table 32).

Trips of less than five km accounted for 39.8% of all trips, thus, it is reasonable to infer that the overall commute distance is short in Taiwan. This result was similar to DGBAS's (2005) study. The total commuting distance for bicycles trips of less than five km accounted for 58.2% in 2003, and the same commuting distance accounted for 49% in 2005.

Table 32. *Commute distance (one-way) of the study participants.*

Variable		Frequency	Percent
Commute distance	<5 km	156	39.8
	6-10 km	100	25.5
	11-15 km	52	13.3
	16-20 km	30	7.7
	>21 km	54	13.8
	Total	392	100.0

(10). Expenses with driving a car

No car fuel expense accounted for the majority of the sample with 151 people or 38.5% of the sample; no car parking fees accounted for the majority of the sample for 309 people or 78.8% of the sample (See Table 33).

Table 33. *Expenses with driving a car of the study participants.*

Variable		Frequency	Percent
Car (fuel)	None	151	38.5
	<NT$1,000	52	13.3
	NT$1,001-2,000	57	14.5
	NT$2,001-3,000	54	13.8
	>NT$3,001	78	19.9
	Total	392	100.0
Car (parking fees)	None	309	78.8
	<NT$1,000	50	12.8
	NT$1,001-2,000	13	3.3
	NT$2,001-3,000	10	2.6
	>NT$3,001	10	2.6
	Total	392	100.0

(11). Motorcycle riding expenses

No motorcycle fuel expense accounted for the majority of the sample with 144 people or 36.7% of the sample; no motorcycle parking fees accounted for majority of the sample with 362 people or 92.3% of the sample (See Table 34).

Table 34. *Expenses with riding a motorcycle of the study participants.*

Variable		Frequency	Percent
Motorcycle (fuel)	None	144	36.7
	<NT$200	66	16.8
	NT$200-400	100	25.5
	NT$401-600	50	12.8
	>NT$601	32	8.2
	Total	392	100.0
Motorcycle (parking fees)	None	362	92.3
	<NT$200	21	5.4
	NT$200-400	7	1.8
	NT$401-600	0	0
	>NT$601	2	0.5
	Total	392	100.0

(12). Mass transit expenses

No MRT or bus expense accounted for the majority of the sample with 305 people or 77.8% of the sample; no taxi expense accounted for the majority of the sample with 373 people or 95.2% of the sample (See Table 35).

Table 35. *MRT or bus expenses of the study participants.*

Variable		Frequency	Percent
MRT, bus	None	305	77.8
	<NT$500	56	14.3
	NT$501-1,000	19	4.8
	NT$1,001-2,000	8	2.0
	> NT$2,001	4	1.0
	Total	392	100.0
Taxi	None	373	95.2
	<NT$1,000	17	4.3
	NT$1,001-2,000	1	0.3
	NT$2,001-3,000	1	0.3
	> NT$3,001	0	0
	Total	392	100.0

Bicycle commuting data analysis

The bicycle commuting data of the subjects have six items; they are bicycle commuter, mass transit experience with bicycle, helmet wearing, bicycle commuting history, bicycle commute trips per week, and stolen bicycle experiences.

(1). Bicycle commuter

Participants who were bicycle commuters accounted for 151 of the total or 38.5% of the sample (See Table 36).

Moritz (1997) found that there were 0.3 percent of bicycle commuters of all the commuters in North America. Pucher and Rene (2004) stated that 0.4 percent of commuters were bicycle commuters in the United States. Pucher and Buehler (2005) claimed 1.2 percent of commuters in Canada were bicycle commuters and currently only 2% of the journeys in Britain above one mile are for business (41%) or leisure (31%) (Nottinghamshire County Council, 2000), and Ku (2006) reported that the bicycle share of local trips is 2%.

Except for the Netherlands, Japan, and Denmark, most of the other countries' bicycle commuters are less than two percent. Therefore, there are 38.5% of recreational bicyclists who choose to bicycle commuting, it is possible to infer that there is a strong relationship between recreational cyclists and bicycle commuters.

Table 36. *Bicycle commuter of the study participants.*

Variable		Frequency	Percent
Bicycle commuter	Yes	151	38.5
	No	241	61.5
	Total	392	100.0

(2). Mass transit experience with bicycle

Recreational cyclists without mass transit experiences with a bicycle accounted for the majority of the sample with a total of 103 or 68.2% of the sample (See Table 37).

The mass transit system in Taiwan such as MRT, trains, and buses do not encourage cyclists to bring their bicycles onto the mass transit. The MRT allows cyclists to bring their bicycles onto them; however, they charged an additional NT$100 for a one-way trip. Due to these factors, the recreational cyclists are reluctant to bring their bicycles onto Taiwan's mass transit.

Table 37. *Mass transit experience with bicycle of the study participants.*

Variable		Frequency	Percent
Mass transit experience with bicycle	Yes	48	31.8
	No	103	68.2
	Total	151	100.0

(3). Helmet wearing

Recreational cyclists who wore helmets accounted for the majority of the sample with 101 people or 66.9% of the sample (See Table 38).

Bicycle helmet is the major protective gear for bicyclists; however, 33.1% of recreational cyclists in this study did not wear helmets when commuting by bicycle. The reasons may because the commuting distance was short, lack of space at work or school to store their helmets or the discomfort of wearing a cycling helmet.

Table 38. *Helmet wearing percentage of the study participants.*

Variable		Frequency	Percent (%)
Helmet wearing	Yes	101	66.9
	No	50	33.1
	Total	151	100.0

(4). Bicycle commuting history

Recreational cyclists with two to three years of bicycle commuting experience accounted for the majority of the sample with 57 people or 37.7% of the sample (See Table 39).

Recreational bicycling is a new recreation compared to other recreational activities in Taiwan. Therefore, recreational cycling has a short bicycle commuting history.

Table 39. *Bicycle commuting history of the study participants.*

Variable		Frequency	Percent
Bicycle commuting history	<1 yrs	39	25.8
	2-3 yrs	57	37.7
	4-5 yrs	23	15.2
	6-7 yrs	15	9.9
	>8 yrs	17	11.3
	Total	151	100.0

(5). Bicycle commute trips per week

One to two trips of bicycle commuting trips accounted for the majority of the sample with 50 people or 33.1% of the sample (See Table 40).

There were 37.7% of bicycle commuters who would commute by bicycle more than five times a week; the rest of non-bicycle commuting days they may use other transportation. The reasons that the bicycle commuters do not commute by bicycle every day may be for the following reasons: First, climate, second, picking up family members, third, carrying of heavy or sophisticated goods (e.g. laptop), and fourth, dressing in formal suit.

Table 40. *Bicycle commute trip per week of the study participants.*

Variable		Frequency	Percent
Bicycle commute trip per week	None	0	0
	1-2 trip(s)	50	33.1
	3-4 trip(s)	44	29.1
	5-6 trips	31	20.5
	> 7 trips	26	17.2
	Total	151	100.0

(5). Bicycle commute distance

Recreational cyclists who bicycle commute four to six km accounted for the majority of the sample with 43 people or 28.5% of the sample (See Table 41).

Four to six km and the group more than 13 km have the same 28.5% of the sample; the total of these two groups accounted for 57%. These reasons that the four to six km group accounted for the majority may be because bicycle commuting is competitive with motorized vehicles in the short commute distance, while the group with more than 13 km distance of ride may be doing so to improve their fitness level or to lose weight.

Table 41. *Bicycle commuting distance (one-way) of the study participants.*

Variable		Frequency	Percent
Bicycle commuting history	<3 km	29	19.2
	4-6 km	43	28.5
	7-9 km	19	12.6
	10-12 km	17	11.3
	>13 km	43	28.5
	Total	151	100.0

Constraints to bicycle commuting data analysis

The constraints to bicycle commuting data of the subject have two items; they are weather constraint and the reason(s) incapable for bicycle commute.

(1). Weather constraint

Heavy rain was the major constraint of the bicycle commuting for 78 respondents or 51.7% of the sample; typhoons accounted for 52 people or 34.4% of the sample (See Table 42).

Heavy rains and typhoons accounted for total 86.1% of weather constraints, and both of heavy rains and typhoons have one thing in common, that is heavy rain. Non-motorized vehicles are severely affected by the bad weather, such as raining (Porter et al., 1999); Nankervis (1999) concluded that heavy rain is the most powerful deterrent for bicycling.

Table 42. *Weather constraint of the study participants.*

Variable		Frequency	Percent
Weather constraint	Typhoon	52	34.4
	Heavy rain	78	51.7
	Hot	11	7.3
	Cold	6	4.0
	Other	4	2.6
	Total	151	100.0

(2). The reason(s) not to bicycle commute

Climate was the major reason that constrained recreational cyclists to bicycle commute with 127 people or 32.4% of the sample (See Table 43).

Six of the 12 questions that most recreational cyclists filled in had been recognized as the important reasons for not bicycle commuting.

First, climate: Climate constraints accounted for the majority of the reasons (32.40%) for not bicycle commuting. The two climatic factors that constrain recreational cyclists were heavy rains and typhoons; these two factors constrained recreational cyclists from bicycle commuting. The results correspond with Porter et al. (1999), and Allen et al. (1998) who both found that the use of non-motorized vehicles to be severely affected by the climate.

From May to June, Taiwan has the plum rain season. It rains for consecutive weeks, and it may constrain bicyclists from bicycle commuting. In Taiwan, Taipei has 170 rainy days, Taichung 117, and both Peng-hu and Kaohsiung have 90 rainy days (CWB, 2007). Besides that, is the typhoon season from July to September. On average, three to four typhoons hit Taiwan annually (CWB, 2007).

Second, lack of bikeways: There is literally no commuting bikeway in Taiwan, and riding on shared roadways with cars and motorcycles is the only choice for bicycle commuters; it adds risks for bicycle commuters.

Third, bicycle theft: Compared with other motorized vehicles, bicycles are light and have no identification individually; thus, bicycles are easily stolen. According to this research result, 43.9% of recreational cyclists have bicycles stolen; it is the major factor that constrained bicyclists from bicycle commuting. This result was similar to ECF's (1991) study, the fear of bicycle theft is one of the reasons why people would not choose to own a bicycle or use the bicycles as often as they would like. However, considering that recreational cyclists tend to purchase high-end bicycles, they worry much more about their bicycle got stolen than bicycle commuters who buy economical commuting bicycles.

Fourth, poor air quality: Most Taiwanese are afraid bicycling in polluted air condition may endanger their health; exposure to fine particles is associated with short and long-term adverse health effects on lungs and heart, and my results correspond with Chen's (1999) study.

Fifth, bad pavement: Compared with motorized vehicles, bicycles are less comfortable especially when riding on bad pavement, over manhole covers, construction covers, potholes, painted surface, or over metal bridges which particularly slick and dangerous when wet.

These bad road conditions severely affect the rider's comfort level and could be risky for them.

Sixth, safety: The percentage of motorcycle ownership in Taiwan is the highest in the world; hence, cyclists are at risk while using roadways crammed with motorcycles (Hou, 2005; Demaio & Gifford, 2004). This result corresponds with Rissel's (2003) study; he observed that a common barrier frequently mentioned by people who would like to cycle but do not is concern about safety.

Table 43. *The reason(s) not to bicycle commuting of the study participants.*

The reason(s) not to bicycle commute		Frequency	Percent	Percent within group
Lack of bikeways	Yes	118	30.1	30.10
	No	274	69.9	
	Total	392	100.0	
Safety	Yes	76	19.4	19.39
	No	316	80.6	
	Total	392	100.0	
Climate	Yes	127	32.4	32.40
	No	265	67.6	
	Total	392	100.0	
Lack of bicycle parking facility	Yes	52	13.3	13.27
	No	340	86.7	
	Total	392	100.0	
Family (Have to pick up kids)	Yes	41	10.5	10.46
	No	351	89.5	
	Total	392	100.0	
Bicycles are undependable (e.g. Flat tire, falling chain)	Yes	11	2.8	2.81
	No	381	97.2	
	Total	392	100.0	
The distance is too long to ride a bicycle	Yes	69	17.6	17.60
	No	323	82.4	
	Total	392	100.0	
Poor air quality	Yes	113	28.8	28.83
	No	279	71.2	

	Total	392	100.0	
No bike can meet my commuting needs	Yes	17	4.3	4.34
	No	375	95.7	
	Total	392	100.0	
Bad pavement	Yes	90	23.0	22.96
	No	302	77.0	
	Total	392	100.0	
Bicycle theft	Yes	115	29.3	29.34
	No	277	70.7	
	Total	392	100.0	
Other	Yes	23	5.9	5.87
	No	369	94.1	
	Total	392	100.0	
Grand total		852		217.37

(3). Stolen bicycle experience

Recreational cyclists who had stolen bicycle experiences accounted for 172 people or 43.9% of the sample; recreational cyclists who did not call police while or when the bicycle was stolen accounted for the majority of the sample with 366 people or 93.4% of the sample (See Table 44).

Compared with other motorized vehicles, bicycles are light and have no identification tag on them; thus, bicycles are easily stolen by thieves. There are 43.9% of recreational cyclists who had stolen bicycle experiences; however, only 6.6% of them ever called the police after having their bicycle stolen and the reasons maybe these: first, bicycles have no identification, second, the chance of finding the lost bike is low, and third, bicycles are cheap compared with motorized vehicles.

Table 44. *Stolen bicycle experience of the study participants.*

Variable		Frequency	Percent
Stolen bicycle experience	Yes	172	43.9
	No	220	56.1
	Total	392	100.0

Called police while bicycle was stolen	Yes	26	6.6
	No	366	93.4
	Total	392	100.0

Motivations for bicycle commuting data analysis

The motivations for bicycle commuting data of the subjects have four items; they are the reason(s) to bicycle commute, available bicycle facilities, the most desired facility, and company or school's encouragement(s).

(1). The reason(s) to bicycle commute

The pure enjoyment of riding a bicycle ranked first for the reasons for bicycle commuting with 96 people or 63.6% of the sample (See Table 44).

Six of the 12 questions that most recreational cyclists filled in are recognized as the important reasons for bicycle commuting, and these factors are analyzed below.

First, enjoying riding a bicycle: Enjoying riding a bicycle was the most often cited reason for bicycle commuting with 24.49% of the sample. One possible reason is because the research participants were recreational cyclists, and they took bicycling as a recreational activity, and they also took bicycle commuting as a kind of enjoyment.

Second, improving fitness: Nowadays, the amount of exercise people get is inadequate; therefore, recreational cyclists took bicycle commuting as a way to exercise, and improving fitness levels. This result corresponds with Wadhwa's (1998) study; he discovered that health was cited by almost every respondent as a reason for using a bicycle; almost 70 percent cited it as the most important reason.

Third, saving fuel: Recently, the price of crude oil has gone up and one liter of 95 unleaded petroleum costs NT$28. Since bicycle commuting requires no fuel. According to the EPA, Executive Yuan, R.O.C. (1997), the doubling of bike trips would save about one to three million US dollars on energy costs.

Fourth, being environmental-friendliness: Bicycling, the green mode is an ideal way of traveling from the point of view of energy conservation and environmental friendliness. Besides, lately, global warming and other environmental issues have been recognized as serious problems of the global community; bicycle commuting could effectively reduce pollution levels. This result corresponds with Wadhwa's (1998) study; he discovered that the inexpensiveness of a bicycle and ecological considerations also were cited as the reasons for using a bicycle by about three-quarters of the respondents.

Fifth, controlling weight: There is a growing problem with obesity in Taiwan. The Xinhua news reported that 50% of Taiwanese are overweight and 25% of them are obese. Overweight means the individual has a body mass index (BMI) that is greater than 24. Adult males accounted for 28.9%, adult females accounted for 18.7% of the obesity problem. When obesity was measure as having a BMI (Body Mass Index) greater than 27, males accounted for 15.9%; and females accounted for 10.7% obesity in Taiwan (Department of Health, ROC, 2007).

Bicycle commuting burns no fuel but does burn fat; it is an effective means to control weight. A regular bicycle commuter could burn an extra 10,230 calories (10 km round trip for 40 mins) more than non-bicycle commuters monthly. It is possible to lose 1.5 kilograms if maintaining the same diet during that one month period.

Sixth, commuting distance was short: The total of shorter than five km commute distance accounted for 39.8% in this study. The total of shorter than five km commute distance accounted for 58.2% in 2003, and the total of shorter than five km commute distance accounted for 49% in 2005 (DGBAS, 2005). It is possible to conclude that most bicycle commuters commute less than five km per major trip. Bicycling is competitive with motorized vehicles especially for short distance commuting. According to the Department of Transportation of Taipei City Government (2004), bicycling is the most efficient transport mode in getting to a destination within five km radius if inside a city like Taipei.

Table 45. *The reason(s) to bicycle commuting of the study participants.*

Variable		Frequency	Percent	Percent within group
The reason(s) to bicycle commute				
Saving for fuel	Yes	75	49.7	19.13
	No	76	50.3	
	Total	151	100.0	
Saving for parking	Yes	28	18.5	7.14
	No	123	81.5	
	Total	151	100.0	
Without motorized vehicle	Yes	16	10.6	4.08
	No	135	89.4	
	Total	151	100.0	
Short commuting distance	Yes	29	19.2	7.40
	No	122	80.8	
	Total	151	100.0	
Enjoy riding a bicycle	Yes	96	63.6	24.49
	No	55	36.4	
	Total	151	100.0	
Being Environmentally-friendly	Yes	61	40.4	15.56
	No	90	59.6	
	Total	151	100.0	
Improving fitness	Yes	93	61.6	23.72
	No	58	38.4	
	Total	151	100.0	
Recommended by family or relatives	Yes	6	4.0	1.53
	No	145	96.0	
	Total	151	100.0	
Encouragement from school or company	Yes	6	4.0	1.53
	No	145	96.0	
	Total	151	100.0	
Good mass transit transportation (MRT,	Yes	4	2.6	1.02

train, bus)				
	No	147	97.4	
	Total	151	100.0	
Controlling weight	Yes	38	25.2	9.69
	No	113	74.8	
	Total	151	100.0	
Other	Yes	4	2.6	1.02
	No	147	97.4	
	Total	151	100.0	
Grand total		456	116.31	116.31

(2). Available bicycle facilities

No available bicycle facilities accounted for the majority of the sample with 209 people or 53.32% of the sample (See Table 46).

53.32% of bicycle commuters could not use any bicycle facilities when reached school or office. If such facilities are not provided, this factor can act as a deterrent as people may choose to leave their bikes at home, especially if they are concerned about the risk of bicycle theft or interference while they are away. This result corresponds with Chen's (1999) study; he concluded that Taiwan lacks bicycle lockers and secure parking areas. Moreover, the City of Pittsburgh Bicycle Plan (n.d.) claimed that a major deterrent to using bicycles as a mode of transportation is the lack of secure parking, changing facilities, showers, and other amenities which cyclists need at the end of a trip.

Table 46. *Available bicycle facilities of the study participants.*

Variable		Frequency	Percent	Percent within group
Available bicycle facilities				
Parking racks	Yes	64	16.3	16.33
	No	328	83.7	
	Total	392	100.0	
Parking shed	Yes	101	25.8	25.77
	No	291	74.2	
	Total	392	100.0	

Locker	Yes	24	6.1	6.12
	No	368	93.9	
	Total	392	100.0	
Shower room	Yes	36	9.2	9.18
	No	356	90.8	
	Total	392	100.0	
Other	Yes	20	5.1	5.10
	No	372	94.9	
	Total	392	100.0	
None	Yes	209	53.3	53.32
	No	147	45.8	
	Total	392	100.0	
Grand total		454		115.82

(3). The most desired facility

Parking racks was the most desired facilities with a total 149 respondents wanting such facilities or 38.0 of the sample (See Table 47).

Parking racks and parking sheds accounted for the total of 69.4% of sample. This shows that cyclists consider that bicycle parking was a critical problem. Guit (1993) claimed that good parking facilities not only reduce the risk of bicycle theft, they can increase the importance and status of the bicycle, which in turn will stimulate cycling. This result corresponds to Wadhwa's (1998) study; he noted that a U.S study found the secure parking facilities to be the principal stimulant to bicycle commuting.

Table 47. *The most desired bicycle facility of the study participants.*

Variable		Frequency	Percent
The most desired facility	Parking racks	149	38.0
	Parking shed	123	31.4
	Locker	12	3.1
	Shower room	55	14.0
	Other	8	2.0
	None	45	11.5
	Total	392	100.0

(4). Company or school's encouragement(s)

233 respondents claimed their companies or school provided no encouragement to bicycle commute 59.4% of the sample (See Table 48).

Although bicycle commuting could bring so many advantages to individuals and society, still most companies or schools do not willing encourage employees or students to bicycle commute. The reasons possibly are do to economical factors, or because most companies or schools do not realize the benefits of bicycle commuting.

Table 48. *Company or school's encouragement(s) of the study participants.*

Variable		Frequency	Percent	Percent within group
Company or school's encouragement(s)				
Free bike	Yes	39	9.9	9.95
	No	353	90.1	
	Total	392	100.0	
Financial assistance for buying bike	Yes	67	17.1	17.09
	No	325	82.9	
	Total	392	100.0	
Bicycle commuting reward	Yes	64	16.3	16.33
	No	328	83.7	
	Total	392	100.0	
Bicycle education course	Yes	39	9.9	9.95
	No	353	90.1	
	Total	392	100.0	
None	Yes	233	59.4	59.44
	No	159	40.6	
	Total	392	100.0	
Other	Yes	6	1.5	1.53
	No	397	98.5	
	Total	392	100.0	
Grand total		448		114.29

Chi-Square Test and Analysis

Gender and bicycle commuter

Table 49 shows the Chi-Square statistic χ^2 = 2.187, Df= 1, p= .139 did not reach the .05 significance level, and this means that the relationship between these two variables was independent. Consequently, there was no relationship between gender and bicycle commuter.

Compared with bicycle commuting, recreational bicycle activities and bicycle competitions are highly intensive exercises. There were 38.5% of recreational cyclists who chose to bicycle commute, and female recreational cyclists did not think bicycle commuting was an arduous mean of transport.

Gender and mass transit experience with bicycle

Table 49 shows the Chi-Square statistic χ^2 = 0.429, Df= 1, p= .512 did not reach the .05 significance level, it means that the relationship between these two variables was independent. Consequently, there was no relationship between gender and mass transit experience with bicycling.

With the advent of the two-day weekend and the rise of recreational activities, both males and females have the right to participate in more recreational activities. 31.8% of recreational cyclists have carried their bicycles onto the MRT or train. Once the cyclists reached the destination, they would start their bicycle tours.

Gender and helmet wearing

Table 49 shows the Chi-Square statistic χ^2 = 0.201, Df= 1, p= .654 did not reach the .05 significance level, it means that the relationship between these two variables was independent. Consequently, there was no relationship between gender and helmet wearing.

Bicycle helmets are one of the major protective gears for bicyclists, and 66.9% of recreational cyclists wore helmet when commuting by bicycle. Regardless of gender, recreational cyclists need to wear bicycle helmets to protect themselves.

Gender and bicycle commuting history

Table 49 shows the Chi-Square statistic χ^2 = 1.022, Df= 4, p= .906 did not reach the .05 significance level. This means that the relationship between these two variables was independent. Consequently, there was no relationship between gender and bicycle commuting history.

Without respect to gender, bicycle commuting is environmentally-friendly, fuel-saving, and healthful. Therefore, there was no relationship between gender and bicycle commuting history.

Gender and bicycle commute trip per week

Table 49 shows the Chi-Square statistic χ^2 = 3.583, Df= 3, p= .310 did not reach the .05 significance level. This signifies that the relationship between these two variables was independent. Consequently, there was no relationship between gender and bicycle commute trips per week.

Nowadays, female work participation has increase compared to several decades ago. In some cases, neither males nor females could commute by bicycles because they wore formal clothing or because they needed to transport laptops. Therefore, there was no relationship between gender and bicycle commuting.

Gender and bicycle commute distance

Table 49 above shows the Chi-Square statistic χ^2 = 7.035, Df= 4, p= .134 did not reach the .05 significance level. This means that the relationship between these two variables was independent. Consequently, there was no relationship between gender and bicycle commute distance.

Bicycle commutes of shorter than 12 km accounted for 71.5% of the sample. A 12 km of bicycle commute could be finished within 36 mins in good traffic conditions, both by male and female cyclists. This result did not correspond with Lo and Lin's (2006) study which claimed that women make shorter bicycle trips than men.

Table 49. *Chi-Square Test of gender and bicycle commuting data.*

Chi-Square	Value	Df	Asymp. Sig. (2-sided)
Bicycle commuter	2.187	1	.139
Mass transit experience with bicycle	0.429	1	.512
Helmet wearing	0.201	1	.654
Bicycle commuting history	1.022	4	.906
Bicycle commute trip per week	3.583	3	.310
Bicycle commute distance	7.035	4	.134

Note: *p<.05 **p<.01 ***p<.001

Age and bicycle commuter

Table 50 shows the Chi-Square statistic χ^2 = 17.730, Df= 5, p= .003 did not reach the .05 significance level. This signifies that the relationship between these two variables was not independent. Consequently, there was a relationship between age and bicycle commuting. The contingency coefficient value was 0.208; it did not reach the .05 significance level.

The 26 to 35 year-old group, the 36 to 45 year-old group and 46 to 55 year-old group of recreational cyclists have less inclination to be bicycle commuters; this may due to their job requirements or the longer distance they need to commute.

Age and mass transit experience with bicycle

The Table 50 shows the Chi-Square statistic χ^2 = 7.977, Df= 5, p= .158 did not reached the .05 significance level, it represented that the relationship between these two variables was independent. Consequently, there was no relationship between age and mass transit experience with bicycle.

Age and bicycle helmet wearing

Table 50 shows the Chi-Square statistic χ^2 = 6.627, Df= 5, p= .250 did not reach the .05 significance level. This signifies that the relationship between these two variables was independent. Consequently, there was no relationship between age and helmet wearing.

Age and bicycle commuting history

Table 50 shows the Chi-Square statistic χ^2 = 41.089, Df= 20, p= .004 did not reach the .05 significance level. This means that the relationship between these two variables was not independent. Consequently, there was a relationship between age and bicycle commuting history. The contingency coefficient value was 0.462; it reached the .05 significance level.

The 15-45 age group of recreational cyclists bicycle commuting histories were mostly shorter than five years, while those in the over 45 years old group had bicycle commuting histories of more than six years. The reasons maybe motorized vehicles were not suitable for elderly people, and bicycling is their main means of commuting or they find it more dependable.

Age and bicycle commute trip per week

Table 50 shows the Chi-Square statistic χ^2 = 39.924, Df= 15, p= .000 did reach the .05 significance level, which signifies that the relationship between these two variables was not independent. Consequently, there was a relationship between age and bicycle commute trips per week. The contingency coefficient value was 0.457; it reached the .05 significance level.

The number of trips for the 15 to 45 year-old group to commute by bicycle was mostly one to four trips per week. The number of trips for the 46 to 65 year-old group was mostly five or more. The reason may due to lack of motorized vehicles for the elderly people. Therefore, bicycles may be their major tool of transport.

Age and bicycle commute distance

Table 50 shows the Chi-Square statistic χ^2 = 14.534, Df= 20, p= .802 did not reach the .05 significance level, which means that the relationship between these two variables was independent. Consequently, there was no relationship between age and bicycle commuting distance.

The total of bicycle commutes shorter than 12 km accounted for 71.5% of the sample. A 12 km bicycle commute can be finished within 36 mins with smooth traffic conditions; it is fairly easy to complete such a trip in this time for all age groups.

Table 50. *Chi-Square Test of age and bicycle commuting data.*

Chi-Square	Value	Df	Asymp. Sig. (2-sided)
Bicycle commuter	17.730^{**}	5	.003
Nominal by nominal	0.208^{**}		.003
Mass transit experience with bicycle	7.977	5	.158
Helmet wearing	6.627	5	.250
Bicycle commuting history	41.089^{**}	20	.004
Nominal by nominal	0.462^{**}		.004
Bicycle commute trip per week	39.924^{***}	15	.000

Nominal by nominal	0.457***		.000
Bicycle commute distance	14.534	20	.802

Note: *p<.05 **p<.01 ***p<.001

Occupation and bicycle commuter

Table 51 shows the Chi-Square statistic χ^2 = 25.092, Df= 8, p= .001 did reach the .05 significance level, which means that the relationship between these two variables was not independent. Consequently, there was a relationship between occupation and bicycle commuter. The contingency coefficient value was 0.245; it reached the .05 significance level.

Students and laborers accounted for 53.6% of the bicycle commuters; the researcher supposed that those with physically active occupations have a higher chance to be bicycle commuters such as laborers and students; while military, civil, and teaching personnel, and homemakers are less likely to be bicycle commuters. This result corresponds with Rivera's (2003) study in which he claimed that the most motivated users of the bicycle are students and workers.

Occupation and mass transit experience with bicycle

Table 51 shows the Chi-Square statistic χ^2 = 11.072, Df= 7, p= .136 did not reach the .05 significance level, which means that the relationship between these two variables was independent. Consequently, there was no relationship between occupation and mass transit experience with bicycle.

Occupation and helmet wearing

Table 51 shows the Chi-Square statistic χ^2 = 5.222, Df= 7, p= .633 did not reach the .05 significance level, which signifies that the relationship between these two variables was independent. Consequently, there was no relationship between occupation and helmet wearing.

Occupation and bicycle commuting history

Table 51 shows the Chi-Square statistic $\chi^2 = 51.692$, Df= 28, p= .004 did reach the .05 significance level, which means that the relationship between these two variables was not independent. Consequently, there was a relationship between occupation and bicycle commuting history. The contingency coefficient value was 0.505; it reached the .05 significance level.

Freelancers and workers in agricultural, forestry, fishery, and husbandry have a higher percentage of bicycle commuting compared to other workers with more than eight years of work experience. The reasons are because the people who engage in these occupations do not need to dress formally and they do not need to go to work sites every weekday. Moreover, they have more flexible choices for transport tools compared to workers in other occupations.

Occupation and bicycle commute trip per week

Table 51 shows the Chi-Square statistic $\chi^2 = 32.316$, Df= 21, p= .054 did not reach the .05 significance level, which means that the relationship between these two variables was not independent. Consequently, there was a relationship between occupation and bicycle commute trips per week.

At first, the researcher supposed that freelancers and students had more bicycle commute trips per week because they do not need to dress formally; however, the results showed that there was no relationship between occupation and trips of bicycle commute per week.

Occupation and bicycle commute distance

Table 51 shows the Chi-Square statistic χ^2 = 23.217, Df= 28, p= .722 did not reach the .05 significance level, which signifies that the relationship between these two variables was independent. Consequently, there was no relationship between occupation and bicycle commuting distance.

Table 51. *Chi-Square Test of occupation and bicycle commuting data.*

Chi-Square	Value	Df	Asymp. Sig. (2-sided)
Bicycle commuter	25.092^{***}	8	.001
Nominal by nominal	0.245^{***}		.001
Mass transit experience with bicycle	11.072	7	.136
Helmet wearing	5.222	7	.633
Bicycle commuting history	51.692^{**}	28	.004
Nominal by nominal	0.505^{*}		.004
Bicycle commute trip per week	32.316	21	.054
Bicycle commute distance	23.217	28	.722

Note: *p<.05 **p<.01 ***p<.001

Car ownership and bicycle commuter

Table 52 shows the Chi-Square statistic χ^2 = 13.161, Df= 4, p= .011 did reach the .05 significance level, which means that the relationship between these two variables was not independent. Consequently, there was a relationship between car ownership and bicycle commuting. The contingency coefficient value was 0.011; it reached the .05 significance level.

Recreational cyclists who do not have cars have the higher chance to be bicycle commuters. The reasons may because they have fewer choices of transport modes.

Motorcycle ownership and bicycle commuter

Table 52 shows the Chi-Square statistic $\chi^2 = 5.501$, Df= 4, p= .240 did not reach the .05 significance level, which signifies that the relationship between these two variables was independent. Consequently, there was no relationship between motorcycle ownership and bicycle commuting.

Due to the high percentage of 0.85 motorcycles possessed by each recreational cyclist, nearly every cyclist has one motorcycle. Therefore, there was no relationship between motorcycle ownership and bicycle commuting.

Bicycle ownership and bicycle commuter

Table 52 shows the Chi-Square statistic $\chi^2 = 47.656$, Df= 10, p= .000 did reach the .05 significance level, which means that the relationship between these two variables was not independent. Consequently, there was a relationship between bicycle ownership and bicycle commuting. The contingency coefficient value was 0.329; it reached the .05 significance level.

There were 53 recreational cyclists who did not have bicycles; therefore, recreational cyclists who do not have bicycle have less chance to commute by bicycle due to this structural constraint.

Table 52. *Chi-Square Test of vehicle ownership and bicycle commuter.*

Chi-Square	Value	Df	Asymp. Sig. (2-sided)
Car ownership	13.161^{*}	4	.011
Nominal by nominal	0.180^{*}		.011
Motorcycle ownership	5.501	4	.240
Bicycle ownership	47.656^{***}	10	.000
Nominal by nominal	0.329^{***}		.000

Note: *p<.05 **p<.01 ***p<.001

Marital status and bicycle commuter

Table 53 shows the Chi-Square statistic χ^2 = 6.631, Df= 3, p= .085 did not reach the .05 significance level, which means that the relationship between these two variables was independent. Consequently, there was no relationship between marital status and bicycle commuting.

It was surprising that the marital status had no relationship with bicycle commuting. In the first instance, the researcher supposed that the married group had to pick up children, therefore they could not bicycle commute; however, the statistics show that there was no relationship between marital status and bicycle commuting.

Marital status and mass transit experience with bicycle

Table 53 shows the Chi-Square statistic χ^2 = 9.628, Df= 3, p= .022 did reach the .05 significance level, which means that the relationship between these two variables was not independent. Consequently, there was a relationship between marital status and mass transit experience with bicycle. The contingency coefficient value was 0.245; it reached the .05 significance level.

The single group accounted for 72.9% of mass transit use with bicycle experiences and this may be because that the single group has more leisure time, while the married group has to take care of their family.

Marital status and helmet wearing

Table 53 shows the Chi-Square statistic χ^2 = 3.840, Df= 3, p= .279 did not reach the .05 significance level, which means that the relationship between these two variables was independent. Consequently, there was no relationship between marital status and helmet wearing.

Marital status and bicycle commuting history

Table 53 shows the Chi-Square statistic χ^2 = 8.832, Df= 12, p= .717 did not reach the .05 significance level, which means that the relationship between these two variables was independent. Consequently, there was no relationship between marital status and bicycle commuting history.

Marital status and bicycle commute trip per week

Table 53 shows the Chi-Square statistic χ^2 = 9.018, Df= 9, p= .436 did not reach the .05 significance level, which means that the relationship between these two variables was independent. Consequently, there was no relationship between marital status and bicycle commute trips per week.

At first, the researcher supposed that the married group had to pick up children, therefore they would have fewer bicycle commute trips per week; however, the statistics show that there was no relationship between marital status and bicycle commute trips per week.

Marital status and bicycle commute distance

Table 53 shows the Chi-Square statistic χ^2 = 15.304, Df= 12, p= .225 did not reach the .05 significance level, which means that the relationship between these two variables was independent. Consequently, there was no relationship between marital status and bicycle commuting distance.

Table 53. *Chi-Square Test of marital status and bicycle commuting data.*

Chi-Square	Value	Df	Asymp. Sig. (2-sided)
Bicycle commuter	6.631	3	.085
Mass transit experience with bicycle	9.628*	3	.022
Nominal by nominal	0.245*		.022
Helmet wearing	3.840	3	.279

Bicycle commuting history	8.832	12	.717
Bicycle commute trip per week	9.018	9	.436
Bicycle commute distance	15.304	12	.225

Note: *p<.05 **p<.01 ***p<.001

Usual commute mode and bicycle commuter

Table 54 shows the Chi-Square statistic χ^2 = 188.416, Df= 4, p= .000 did reach the .05 significance level, which signifies that the relationship between these two variables was not independent. Consequently, there was a relationship between usual commute mode and bicycle commuting. The contingency coefficient value was 0.570; it reached the .05 significance level.

Recreational cyclists who took motorized vehicles as transport means were less likely to be bicycle commuters; while the ones who took active transport (bicycling and walking) and mass transportation have the higher chance to be bicycle commuters.

Usual commute mode and mass transit experience with bicycle

Table 54 shows the Chi-Square statistic χ^2 = 5.772, Df= 4, p= .217 did not reach the .05 significance level, which means that the relationship between these two variables was independent. Consequently, there was no relationship between usual commute mode and mass transit experience with bicycle.

Usual commute mode and helmet wearing

Table 54 shows the Chi-Square statistic χ^2 = 1.093, Df= 4, p= .895 did not reach the .05 significance level, which means that the relationship between these two variables was independent. Consequently, there was no relationship between usual commute mode and helmet wearing.

Usual commute mode and bicycle commuting history

Table 54 shows the Chi-Square statistic χ^2 = 15.894, Df= 16, p= .460 did not reach the .05 significance level, which means that the relationship between these two variables was independent. Consequently, there was no relationship between usual commute mode and bicycle commuting history.

Usual commute mode and bicycle commute trip per week

Table 54 shows the Chi-Square statistic χ^2 = 24.441, Df= 12, p= .018 did reach the .05 significance level, which signifies that the relationship between these two variables was not independent. Consequently, there was a relationship between usual commute mode and bicycle commute trips per week. The contingency coefficient value was 0.373; it reached the .05 significance level.

Recreational cyclists who took motorized vehicles as their commute mode had fewer bicycle commute trips per week. The reasons may because that they had more transport mode choices so that when there was bad weather conditions, or when they needed to go shopping, go on dates or attend meetings, they might opt not to bicycle commute.

Usual commute mode bicycle commute distance

Table 54 shows the Chi-Square statistic χ^2 = 10.275, Df= 16, p= .852 did not reach the .05 significance level, which means that the relationship between these two variables was independent. Consequently, there was no relationship between usual commute mode and bicycle commuting distance.

Table 54. *Chi-Square Test of usual commute mode and bicycle commuting data.*

Chi-Square	Value	Df	Asymp. Sig. (2-sided)
Bicycle commuter	188.416^{***}	4	.000
Nominal by nominal	0.570^{***}		.000
Mass transit experience with bicycle	5.772	4	.217
Helmet wearing	1.093	4	.895
Bicycle commuting history	15.894	16	.460
Bicycle commute trip per week	24.441^{*}	12	.018
Nominal by nominal	0.373^{*}		.018
Bicycle commute distance	10.275	16	.852

Note: *p<.05 **p<.01 ***p<.001

Car fuel expense and bicycle commuter

Table 55 shows the Chi-Square statistic χ^2 = 19.211, Df= 4, p= .001 did reach the .05 significance level, which means that the relationship between these two variables was not independent. Consequently, there was a relationship between bicycle commuting and car fuel expense. The contingency coefficient value was 0.216; it reached the .05 significance level.

Obviously, bicycle commuting requires no fuel. Therefore, recreational cyclists who commute by bicycle could save on fuel expenses.

Car parking fees and bicycle commuter

Table 55 shows the Chi-Square statistic χ^2 = 7.557, Df= 4, p= .109 did not reach the .05 significance level, which signifies that the relationship between these two variables was independent. Consequently, there was no relationship between bicycle commuting and car parking fees.

For recreational cyclists who chose bicycle commuting, they possessed automobiles while their major commute mode was bicycle commuting. Therefore, they still needed to pay parking fees for their car(s), and there was no relationship between bicycle commuting and parking fees.

Motorcycle fuel expense and bicycle commuter

Table 55 shows the Chi-Square statistic χ^2 = 11.132, Df= 4, p= .025 did reach the .05 significance level, which means that the relationship between these two variables was not independent. Consequently, there was a relationship between bicycle commuting and motorcycle fuel expenses. The contingency coefficient value was 0.166; it reached the .05 significance level.

Compared with motorized vehicles, bicycle commuting requires no fuel. Therefore, the bicycle commuters could save on fuel expenses by bicycle commuting.

Motorcycle parking fees and bicycle commuter

Table 55 shows the Chi-Square statistic χ^2 = 7.295, Df= 3, p= .063 did not reach the .05 significance level, which signifies that the relationship between these two variables was independent. Consequently, there was no relationship between bicycle commuting and motorcycle parking fees.

For the recreational cyclists who chose to bicycle commuting, they own motorcycles but their major commute mode was bicycle commuting. Therefore, they still needed to pay motorcycle parking fees, and there was no relationship between bicycle commuting and motorcycle parking fees.

Mass transportation expenses and bicycle commuter

Table 55 shows the Chi-Square statistic χ^2 = 8.717, Df= 4, p= .069 did not reach the .05 significance level, which means that the relationship between these two variables was independent. Consequently, there was no relationship between bicycle commuting and mass transportation expenses.

It is nearly impossible that a bicycle is the only commuting mode for the bicycle commuter; bicyclists who travel to distance places require mass transit to carry them to those faraway places, and mass transit plays as complementary transportation role to bicycle commuting.

Taxi expense and bicycle commuter

Table 55 shows the Chi-Square statistic $\chi^2 = 2.298$, Df= 3, p= .513 did not reach the .05 significance level, which signifies that the relationship between these two variables was independent. Consequently, there was no relationship between bicycle commuting and taxi expenses.

Bicycle commuters still need to take taxis when the bicycle cannot meet their needs. For example, when weather conditions are bad, or for shopping, or attending meetings. On these occasions a taxi can be a complementary mode of transportation.

Table 55. *Chi-Square Test of transportation expenses and bicycle commuter.*

Chi-Square	Value	Df	Asymp. Sig. (2-sided)
Car fuel expense	19.211^{***}	4	.001
Nominal by nominal	0.216^{***}		.001
Car parking fees	7.557	4	.109
Motorcycle fuel expense	11.132^{*}	4	.025
Nominal by nominal	0.166^{*}		.025
Motorcycle parking fees	7.295	3	.063
Mass transportation expenses	8.717	4	.069
Taxi expense	2.298	3	.513

Note: *p<.05 **p<.01 ***p<.001

Chapter 5

DISSCUSSION

In this chapter, the discussion and analysis will be provided based on the findings of this research. Also, a comparison will be made with related research results, and then analysis and discussion. Furthermore, a synthesis of the conclusion of the study will be made as well as proposed research findings and suggestions to the bicycle industry, government and academics. Research limitations and directions for future research will also be made in this chapter.

This chapter will also examine the findings, discussed the results of the research questions here, and hypothesize the possible answers to the true and null hypotheses. Below are the answers and suppositions of this research.

Findings

The researcher proposed five research questions according to the purposes of the study:

(1). There were 38.5 % of recreational cyclists who chose to bicycle commute in this study. It is possible to infer that recreational cyclists have a preference for bicycle commuting, and the possibilities are higher for other groups.

(2). The reasons why recreational cyclists may not wish to bicycle commute can be summarized into six reasons: First, climate, second, lack of bikeways, third, bicycle theft, fourth, poor air quality, fifth, bad pavement, and sixth, safety.

(3). The motivations for recreational cyclists to bicycle commute can also be summarized by the following six reasons: First, enjoying riding a bicycle, second, improving fitness, third, saving fuel, fourth, being environmentally-friendly, fifth, controlling weight, and sixth, short commuting distances.

(4). Here, the researcher referred to Pucher, Komanoff, and Schimek (1999) and proposed cycling awareness programs and bicycle policy that may stimulate bicycle commuting.

Suggested cycling awareness programs are as follows: first, programs to encourage students to use bicycles, second, education of motorists about cyclists' rights, third, promotion of biking, not just for recreational purposes, but also bicycle commuting, fourth, organization of mass events such as Bike to Work Day/week and employer-based promotions to publicize cycling and raise community and political support, fifth, organization of large-scale bike tours in and around cities, sixth, education on how to avoid unnecessary driving, maintaining the car properly and driving wisely, seventh, linkage of cycling to wellness by showing its health benefits in providing an ideal cheap means for exercise, eighth, changing the attitude of the public toward non-motorized use, ninth, lessening cultural and institutional bias against green modes of transport, tenth, creation and organization of bicycling groups that can also contract with professional educators and trainers to provide cycling programs through schools, community centers, bicycle clubs, etc., and finally, establishment of car free days in certain streets, areas or towns.

Suggested bicycling policies are as follows: first, initiating extensive awareness campaigns to encourage non-motorized modes of transport, such as promoting the idea in public and school programs, second, establishing bicycle lanes, third, making all roads "bikeable", through both physical adaptations and enforcement of cyclists' rights in using the roads, fourth, enforcing the government and encouraging them to adopt non-motorized modes of transport policies, and implementing them (one possible solution for Taiwan is to replace the old, non-usable railways by new, more effective bikeways where applicable), fifth, initiating a city-bike racks program to install bicycle parking spaces on sidewalks, also applicable are bike-bus connections to combine bicycle and public transportation, sixth, having urban and road design characteristics that ensure the safety of pedestrians and bicyclists, seventh, designing car-free areas where access is restricted for non-motorized modes of transport, eighth, making driving more difficult and expensive such as congestion fee, and finally, prevention of bicycle theft.

Significance of the Study and Suggestions

There are large amounts of research about recreational bicycling, however; only two of theses have been made so far by High School students about bicycle commuting and feasible bikeways in a sustainable city (C. X. Chang, 2004; Hou, 2005). No studies have ever tried to investigate bicycle commuting by recreational cyclists in Taiwan. The researcher tried to make a step forward to investigate the system to increase the bicycle commuting population. Hopefully the results can be used for governmental organizations or bicycle related studies. By proposing better bicycle commuting methods, we can anticipate having better bicycle commuting conditions in Taiwan. This will lead to a more natural, healthier and beautiful island which is called “Formosa”.

Academics

This is the first study aimed at discovering the relationship between recreational cyclists and bicycle commuting. Recreational cyclists have more bicycling experiences than the general public, and it is possible to deeply examine the motivations and constraints of recreational cyclists to bicycle commuting. The research findings can be a reference for other bicycle related researchers.

Bicycle industry

Climate issue: 51.7% of the bicycle commuters recognized rain as one major constraint to bicycle commuting. Therefore, the bicycle manufacturers could consider to design a bicycle raincoat and a bicycle canopy (a bicycle roof), to reduce the constraints of the climate to bicycle commuting.

Bicycle theft: 43.9% of recreational cyclists have had the experiences of having had their bicycle lost or stolen. Bicycle theft was the second major constraint to bicycle commuting. Therefore, the bicycle part manufacturers could devise a built-in chip for bicycles and build secure bicycle locks and parking racks.

Government

Bicycle facilities: from the responses of recreational cyclists, bicycle related officers could possibly be made to better understand the general situation of Taiwanese bicycle commuters. The most desired facility is bicycle racks which accounted for 38.0% of recreational cyclists requests; hence, such facilities should be planned and constructed to increase the bicycle commuting rate.

Lost bicycles: recreational cyclists had a 43.9% of bicycle lost experiences rate. This showed that having bicycles stolen is a serious concern. However, only 6.6% of the cyclists called police while 93.4% of the cyclists did not call the police because they did not believe their bicycle would be found. The police find it difficult to search for lost bicycles because bicycles are not equipped with identification tags. The researcher suggests that the police should investigate the bicycles being sold in secondhand markets. This would hopefully eliminate the channel of selling lost bicycles; besides, bicycle related organizations may devise bicycle racks, to make it easier to secure bicycle frames and wheels. This would hopefully reduce the possibility of bicycle theft.

Advertisements: 38.5% of recreational cyclists also bicycle commute. It is recommended to promote bicycle commuting by advertising that it is environmentally-friendly, saves fuel and helps to improve fitness. Posters could be put up to heighten the benefits of bicycle commuting at local bicycle shops and at bicycle activities. This could elevate the public's inclination to bicycle commute.

Limitation and Directions for Future Research

Limitation

The sampling of this research adopted convenience sampling and focused on recreational cyclists. Most bicycle commuters are not bicycle club members. Furthermore, some bicycle club members do not bicycle commute. Thus, the research results could not be generalized to the whole Taiwanese bicycle commuting population.

Follow-up suggestions

Research scope

Most bicycle activity research has focused on recreational bicycling or competitive cycling. This research was only a preliminary study of the relationship between recreational cyclists and bicycle commuting. The issue should be further discussed in the future. The sampling of the study focused on recreational cyclists, thus, the research results can not be generalized to the whole bicycle commuter population. The researcher suggests that future research could adopt random stratified sampling, and focus on all Taiwanese to discover the bicycle commuter's situation. It could represent the real bicycle commuting situation in Taiwan.

Extensive related research

Nowadays, Taiwan still lacks sufficient bicycle commuting related studies. Possible future studies could focus on bicycle transit, the benefits of bicycle commuting and other bicycle commuting related issues. We could discover the feasibility of bicycle transit to the MRT and the bus, student's bicycle commuting motivations and constraints, as well as physical and economical benefits created by bicycle commuting.

Recently, the Taiwanese government strongly implemented the bicycle commuting policy which encouraged elementary school students to bicycle commute; however, the effect was poor. It is possible to discover the difficulties of bicycle commuting implementations from the government in Taiwan.

Conclusions

It is unrealistic to aim to remove the motorized vehicles from all areas in Taiwan; however we are in a position where we can build on existing alternatives for car use, and each country requires a specific policy that could be implemented according to the socioeconomic situation in that country. To make cycling more attractive to more people, the bicycle needs to be competitive with the automobile. Providing bicycle routes that minimize travel time will be important to affecting a person's decision to opt for the bicycle instead of the car.

It might be hard to promote bicycle use due to safety reasons at the present time. Still, building separate bicycle lanes and establishing bike racks, lockers and showers in future development strategies can advocate cycling to a greater extent.

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APPENDIX A

BICYCLE COMMUTING QUESTIONNAIRE

Hello: This is an academic research questionnaire, the purpose is to discover the bicycle commuting situation and personal commuting status, and the research results can be a reference for bikeway designers and researchers. This questionnaire maintains anonymity so please fill it out according to your real situation. The data will be only used for nothing but research analysis. Please help by filling this questionnaire and thank you.

Best regards,

National Taiwan College of Physical Education Graduate School of Recreational Sports Management

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I. About your household

1. Gender

☐male ☐female

2. Age

☐<15 yrs ☐16-25 yrs ☐26-35 yrs ☐36-45 yrs

☐46-55 yrs ☐56-65 yrs ☐>66 yrs

3. Occupation

☐Student ☐Military, Civil, and Teaching Personnel ☐Service Industry ☐Homemaker ☐Laborer

☐Businessman ☐Freelancer ☐Agricultural, Forestry, Fishery, and Husbandry ☐Other______ (Please specify)

4. How many vehicles you have? ______Car(s) ______ Motorcycle(s) ______Bicycle(s)

5. Marital status

☐Unmarried ☐Married (no kids)

☐Married (kids under or in elementary school) ☐Married (kids above or in junior high school)

II. About your commuting

The definition of bicycle commuter was defined as one that used a bicycle at least once per week, for three months for at least half of the year.

1. What is your USUAL (>50%) commute mode?

☐Car ☐Motorcycle ☐Bike ☐Walk ☐Transit

2. What is your ONE-WAY commute distance? (the distance from home to office or school)

☐<5 km ☐6-10 km ☐11-15 km ☐16-20 km ☐>21 km

3. Are you a bicycle commuter? ☐Yes(Continue) ☐No(Please proceed to question 11)

4. Have you ever taken bicycle onto mass transportation (MRT, Train, Bus)? ☐Yes ☐No

5. Do you wear a helmet while bicycle commuting? ☐Yes ☐No

6. How long have you been bicycle commuting?

☐<1 yrs ☐2-3 yrs ☐4-5 yrs ☐6-7 yrs ☐>8 yrs

7. How many trips do you bicycle commute within a week (One trip equals to two ways)?

☐none ☐1-2 trip(s) ☐3-4 trips ☐5-6 trips ☐>7 trips

Please Proceed to Page 2

8. How far do you “bicycle commute” each time?

☐<3 km ☐4-6 km ☐7-9 km ☐10-12 km ☐>13 km

9. What is the most direct constraint that affects your bicycle commuting? (Single choice)

☐Typhoon ☐Heavy rain ☐Hot temperature ☐Cold temperature ☐Other____

10. What is(are) the reason(s) you choose to bicycle commute? (Multiple choice)

☐Saving fuel ☐Saving parking ☐Without motorized vehicle
☐Commuting distance was short ☐Enjoy riding a bicycle ☐Environmentally-friendly
☐Improving fitness ☐Recommended by family or relatives ☐Encouragement from school or company
☐Good mass transit (MRT, train, bus) ☐Controlling weight ☐Other________

11. If you do not use bicycle commuting or bicycle commuting every time, what is(are) your most important reason(s)? (Single choice)

☐Lack of bikeways ☐Safety ☐Climate
☐Lack of bicycle parking facility ☐Family (Have to pick up kids) ☐The bicycles are undependable (e.g. Flat tire, falling chain)
☐The distance is too long to ride a bicycle ☐Poor air quality ☐No bike can meet my commuting needs
☐Bad pavement ☐Bicycle theft ☐Other________

III. About your facility

1. What facilities can you use at your commuting destination (e.g. School or company)? (Multiple choice)

☐Parking racks ☐Parking shed ☐Lockers
☐Shower room ☐Other_______ ☐None

2. What is your most desired bicycle facility at commuting destination? (Single choice)

☐Parking racks ☐Parking shed ☐Locker
☐Shower room ☐Other_______ ☐None

3. How has your company or school encouraged you to bicycle commute? (Multiple choice)

☐Free bike ☐Financial assistance for buying bike ☐Bicycle commuting reward
☐Bicycle education course ☐None ☐Other_______

IV. About your commuting expenses

This part is to sum up your commuting expenses “each month”, and it divided into car, motorcycle and mass transportation commuting.

1. Car

Fuel	☐None	☐<NT$1,000	☐NT$1,001-2,000	☐NT$2,001-3,000	☐> NT$3,001
Parking fee	☐None	☐<NT$1,000	☐NT$1,001-2,000	☐NT$2,001-3,000	☐> NT$3,001

2. Motorcycle

Fuel	☐None	☐<NT$200	☐NT$200-400	☐NT$401-600	☐> NT$601
Parking fee	☐None	☐<NT$200	☐NT$200-400	☐NT$401-600	☐>NT$601

3. Mass transportation

MRT, Bus	☐None	☐<NT$500	☐NT$501-1,000	☐NT$1,001-2,000	☐> NT$2,001
Taxi	☐None	☐<NT$1,000	☐NT$1,001-2,000	☐NT$2,001-3,000	☐> NT$3,001

V. About bicycle theft

1. Have you ever lost a bicycle? ☐Yes ☐No
2. Have you called the police after losing your bicycle? ☐Yes ☐No

VI.

Suggestion:____

This questionnaire design was referred to Moritz (1997) Survey of Regular Bicycle Commute

Thank You

Appendix B

CHINESE QUESTIONNAIRE

單車通勤問卷調查

您好，這是一份學術性的問卷，目的在於瞭解台灣自行車通勤環境及個人通勤狀況，以做為自行車道設計者、學者參考。問卷採不記名方式，請依實際情形回答。所有資料僅用於研究分析，絕不做為其他用途，敬請放心填寫。

敬祝 健康平安

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壹、基本資料

一. 性別

□男　□女

二. 年齡

□15 歲以下　□16 歲至 25 歲　□26 至 35 歲　□36 歲至 45 歲

□46 至 55 歲　□56 至 65 歲　□66 歲以上

三. 職業

□學生　□軍公教　□服務業　□家管　□工

□商　□自由業　□農林漁牧業　□其他__________（請列出）

四. 您有幾部交通工具？_____輛汽車_____部機車_____輛腳踏車

五. 婚姻狀況

□未婚　□已婚(無小孩)

□已婚，小孩唸國小以下　□已婚，小孩唸國中以上

貳、通勤部份

本研究對於單車通勤者的定義為：「每週至少單車通勤一次，並且在半年中有三個月以上都利用單車做為通勤工具」。

一. 您經常(大於 50%)使用何種方式通勤？

□汽車　□機車　□單車　□步行　□大眾運輸

二. 您單「程」的通勤距離幾公里(家至公司或學校的距離)？

□5 公里以下　□6 至 10 公里　□11 至 15 公里　□16 至 20 公里　□21 公里以上

三. 您是否為單車通勤者？　□是(請續答)　□否(請至第十一題回答)

四. 您是否曾騎自行車轉乘大眾運輸 (捷運、火車、公車)？　□是　□否

五. 您單車通勤時是否配帶安全帽？　□是　□否

六. 您已持續利用單車通勤多久了？

□1 年以下　□2 年至 3 年　□4 年至 5 年　□6 年至 7 年　□8 年以上

問卷共二頁，背面尚有題目，謝謝

七. 您一週內單車通勤幾次(來回為一趟)？

□無　□1 至 2 趟　□3 至 4 趟　□5 至 6 趟　□7 趟以上

八. 您單程的「單車」通勤距離幾公里？

□3 公里以下　□4 至 6 公里　□7 至 9 公里　□10 至 12 公里　□13 公里以上

九. 哪項天候因素為降低您單車通勤意願的主因？(單選)

□颱風　□大雨　□酷熱　□寒流　□其他_______

十. 您選擇單車通勤的因素為何？(可複選)

□節省燃料費　□節省汽、機車停車費　□無機動交通工具

□通勤距離短　□喜歡騎單車　□減少空氣污染

□提昇體能　□家人、親友推薦　□公司或學校鼓勵單車通勤

□完善的大眾轉乘運輸（捷運、火車、公車）　□減輕體重　□其他________

十一. 請述您不以單車通勤或不完全以單車通勤的原因？(可複選)

□缺少單車專用道　□個人安全　□氣候因素

□公司或學校缺乏單車停放設備　□家人因素（必需接送小孩）　□單車可靠性不佳（e.g. 爆胎、掉鏈）

□通勤距離過遠　□空氣品質差　□沒有適合自已通勤的單車

□不良的道路品質　□單車易失竊　□其他___________

參、設備部份

一. 在您所抵達的終點(e.g. 公司、學校)提供何種單車設備？(可複選)

□單車停車架　□單車置車棚　□置物櫃

□淋浴間　□其他______　□無

二. 您「最希望」在您抵達的終點提供何種單車設備？(單選)

□單車停車架　□單車置車棚　□置物櫃

□淋浴間　□其他______　□無

三. 您所屬的學校或公司藉由以下哪些方法鼓勵單車通勤？(可複選)

□免費提供單車　□購單車補助　□單車通勤獎勵

□單車教育課程　□無　□其他_______

肆、通勤費用部份

本項在統計您「每月」所支出的通勤費用，共分為汽車通勤、機車通勤以及大眾運輸通勤。

一. 汽車部份

燃料費	□無	□1,000 元以下	□1,001-2,000 元	□2,001-3,000 元	□3,001 元以上
停車費	□無	□1,000 元以下	□1,001-2,000 元	□2,001-3,000 元	□3,001 元以上

二. 機車部份

燃料費	□無	□200 元以下	□201-400 元	□401-600 元	□601 元以上
停車費	□無	□200 元以下	□201-400 元	□401-600 元	□601 元以上

三.大眾運輸部份

捷運、公車	□無	□500 元以下	□501-1,000 元	□1,001-2,000 元	□2,001 元以上
計程車	□無	□1,000 元以下	□1,001-2,000 元	□2,001-3,000 元	□3,001 元以上

伍、單車失竊部分

一. 您是否曾遺失單車？ □是 □否

二. 您單車遺失時是否報警？ □是 □否

陸、建議事項：______________________________

本問卷參考 Moritz (1997) Survey of Regular Bicycle Commuter

問卷結束，謝謝您的合作