Estimating recreational cyclists' preference on bicycle route facility -Evidence from Taiwan

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ABSTRACT

This paper aim to examine recreational cyclists' preference on bicycle route facility attributes using stated preference analysis in Taiwan. The logit models is employed to estimate the relative influences of facility attributes on bicycle route choice behaviour. The multinomial logit model with interactions and latent class logit are estimated to account for heterogeneity in the preference of facility attributes for bicycle route. In addition, recreational specialization is taken into account when predicting bicycle route choice for particular group. The latent class model is estimated with recreational specialization in segment membership that allow for testing latent heterogeneity in bicycle route and facility attributes. The results indicate that bicycle facility attributes such as toilet and simple maintain equipment, tourist information center, attraction, and bike path in bicycle route facility exhibit significant effects on recreational cyclists preferences. Results of latent class model reveal that high level of recreational specialization cyclists are more likely than low recreational specialization cyclists to choice challenge and endurance grading route.

Keywords: recreational cyclist, heterogeneity, latent class logit, stated preference

INTRODUCTION

Cycling is an environmentally friendly mode of transportation and has become a newly and popularly recreational activity during past decades. Ritchie (1998) has indicated that cycle tourism becomes an increasingly important activity and a type of tourism interest. A number of cyclists are increasing in many countries, for instance, France, New Zealand, UK, North American etc. Also, they are eager to construct cycle routes to meet an increasing demand for recreation and tourism purpose. However, governments and planners have neglected the user demand while planning for the bicycle facilities. Therefore, understanding cyclists' preference in terms of bicycle service attributes can provide insightful information for managerial policy-making planning.

Previous studies have examined factors that influence on bicycle route choice, including personal characteristics, environment component, bicycle facility, and recreation specialization (Chang & Chang, 2009; Sener, Eluru & Bhat, 2009; Stinson & Bhat, 2003; Tilahun, Levinson & Krizek, 2007). Bryan (1977) has suggested that diversity among participants in recreational activity could be understood in term of the grade of specialization exhibited by the participant within that activity. Thus, with increasing of riding experience, cyclists would show greater preference for bicycle equipment and be more likely to challenge a difficult cycle route. Besides, the diversity of recreational specialization will affect cyclists' preferences for route choice. This heterogeneity should be taken into account when predicting bicycle route choice for particular group. Therefore, we assume that there is heterogeneity in the high specialization groups' preferences for particular bicycle facility.

In the approach of distribute choice modeling, a stated preference (SP) method, has appeared as an attractive tool as the multi-attribute framework and has confirmed to be particularly useful as a theoretical structure for transportation, marketing, leisure, tourism, etc. A common reason why the SP method has become so popular is due to their ability to transform consumer decisions made into real markets; otherwise , they would be difficult to be observed (Rose, Hensher & Greene, 2005). The multinomial logit model (MNL) has been frequently and effectively applied to analyze the SP data and to explore tradeoffs that consumers are willing to pay between two attributes of products and services. Additionally, latent class model is used to test for heterogeneity in bicycle route choice behavior of recreational cyclists, and to identify segments of this recreational cyclist group.

This study focuses on the recreational cyclists preference evaluation on service attributes of bicycle route by stated preference (SP) method and employs logit models to estimate the relative influences of service attributes on choice behavior of recreational cyclists. The SP experiments have been widely applied to a variety of research fields, including transportation, marketing, environment, health, leisure and recreation; however, rarely research has been conducted on the SP in the bicycle route facility. Therefore, the objective of this study is to valuate of recreational cyclists' preference and evaluate how or whether each segment of recreational specialization level of cyclists will affect the different preference of service attributes. The empirical results should be useful for governments in building up more cycle route networks and providing better cycling facilities by considering cyclist characteristics and their environmental preferences.

LITERATURE REVIEW

Research on bicycle route choice

SP method has been widely used to analyze attributes of cyclists' preference in bicycle route choice behavior (Hunt & Abraham, 2007; Sener et al., 2009; Stinson & Bhat, 2003; Tilahun et al., 2007; Ortuzar, Iacobelli &Valeze, 2000). These studies have investigated the preference of commuting and recreational cyclists, attributes of influence bicycle route choice, including bicyclist characteristics, bikeway width, parking facility, traffic volume, speed limit, continuity, pavement quality, traffic stops, travel cost and travel time. However, with different trip purpose of cyclists, they will have different preference of bicycle facility attributes (Antonakos, 1994; Sener et al., 2009). Therefore, this study only focuses on investigating recreational cyclists' preference in cycling facility attributes.

Regarding the effect of attributes upon recreational cyclists' preference of bicycle route choice, past studies have identified some factors, such as personal characteristics, level of cycling experience, bicycle lane type, pavement, roadway grade, and scenery (Antonakos, 1994; Sener et al., 2009). Sener et al. (2009) have investigated cyclist preference for attribute of bicycle route choice by using SP survey in Texas. They proposed attributes of influence bicycle route choice, including bicyclist characteristics, on-street parking type, bicycle lane type, roadway grade, traffic volume, speed limit, and travel time. The results revealed that commuting and recreational cyclists have different preferences on service attribute, for instance, commuter cyclists prefer the route with no parking and lower traffic volume, and recreational cyclists prefer the bicycle route along roadways with moderate to steep hills. Moreover, Chang and Chang (2009) have explored recreational cyclists' bicycle environmental preferences in Taiwan. The results indicated that bicycle path right of way separate from road is most important attribute for recreational cyclist. In addition, with increasing age and experience, recreational cyclists are mainly preference for bicycle lanes and wide curb lanes instead of bicycle paths, and trails (Antonakos, 1994)

Recreation specialization

Bryan (1977) first proposed the conceptual framework of recreation specialization to describe trout anglers in Idaho, Montana, and Wyoming. The recreation specialization was defined as "a continuum of behavior from the general to the particular specialization, reflected by equipment and skill used in the sport and activity setting preferences". Nowadays, the conceptual of recreation specialization has applied to many different types of outdoor recreation activities, such as hiking, camping, boating, fishing, hunting etc. In Bryan's initial conceptualization, it is emphasis on behavioral and cognitive aspects of specialization with a few indicators such as equipment and skill. Subsequently, McIntyre(1989) have argued that merely using single-dimensional approach or multi-dimensional (behavioral and cognitive) would result in inconsistency aspects and limitation.

McIntyre and Pigram (1992) have proposes multi-dimensional of recreation specialization components, such as a behavioral (e.g., experience), a cognitive (e.g., level of skill), and an affective dimension (e.g., enduring involvement); these components are interrelated and mutually reinforcing. Subsequently, some researchers have used these three dimensions to measure the level of recreation specialization (Bricker and Kerstetter ,2000；Mcfarlane ,2004；Oh & Ditton, 2006). In this study, we will use these three dimensions to measure cyclists' specialization.

METHOD

Model specification

A random utility theory as the theoretical basis of discrete choice models (McFadden, 1974) was used in this research. The random utility maximization theory starts from the assumption that individuals can generate their market behavior by maximizing the utility of preferences. This study implements the random utility model to explain individual choices by specifying functions for the utility derived from the available alternatives. The utility function is estimated using a multinomial logit model (MNL) premised that choices are consistent with an independence from the irrelevant alternatives (IIA) property; and herein, IIA indicates that, the ratio of choice probabilities in any two alternatives for any individual is entirely unaffected by the systematic utilities of any alternatives. Assuming utility-maximizing behavior by the decision maker, the indirect utility function U_{ij} for each respondent i who chooses alternative j in the choice set *Ci* can be expressed as:

$$U_{ij} = V_{ij}\left(X_{ij}, Z_i\right) + \varepsilon_{ij} = bX + dZ + \varepsilon_{ij} \quad (1)$$

The utility function U_{ij} can be decomposed into the determinant part V_{ij} , which typically is specified as a function of deterministic components including a vector of service attributes (X) and individual characteristics (Z). Besides, the error term ε_{ij}, which represents the unobservable individual characteristics, can influence on choices (Louviere, et al., 2000). Furthermore,β represents a vector of coefficients estimated for individual preference on service attributes in this study, and δ represents a vector of coefficients estimated for individual characteristics.

The dependent variable of Eq. (1) represents individual choice behavior, and it is a discrete variable. If $U_{ij}>U_{ik}$ for all $j \neq k$ in the choice set C_i, then the probability that respondent i will select alternative j over k is given by:

$$P\left(j \mid C_i\right) = P\left(V_{ij} + \varepsilon_{ij} > V_{ik} + \varepsilon_{ik}\right) = P\left(V_{ij} - V_{ik} > \varepsilon_{ik} - \varepsilon_{ij}\right) \quad (2)$$

The probability above depends on the hypotheses formulated about the distribution of the random vector of error terms. If the error term ε_{ij} were independently and identically distributed (IID) Gumbell distributions would across the population (Ben-Akiva & Lerman, 1985), then a standard logit model or multinomial logit model (MNL) is applicable. With the MNL model, the probability$P(j \mid C_i)$ can be expressed as:

$$P_{ij} = \frac{\exp(V_{ij})}{\sum_{k \in C_i} \exp(V_{ik})} \quad (3)$$

The Latent Class model (LCM) approach is also applied into the estimation. Compared to MNL and ML in discrete choices, the LCM approach allows the analysts to observe individual heterogeneity through identifying and characterizing various preference groups (Louviere et al., 2000). The LCM assumes that the population consist of a number of latent classes *S* and the unobserved heterogeneity among individuals can be captured by these classes through estimating a different parameter vector in the corresponding utility function. Formally, the choice probability of individual *i* choosing alternative *j* of class *S* is expressed as:

$$P_i(j) = \sum_{s=1}^{s} P_i(j \mid S) \cdot H_i(S) \quad (4)$$

Where

$$P_i(j \mid S) = \frac{\exp(V_{ij})}{\sum_{j' \in C_i} \exp(V_{ij})} \quad (5)$$

$$H_i(S) = \frac{\exp(\theta_s^{'} Z_i)}{\sum_{s=1}^{s} \exp(\theta_s^{'} Z_i)} \tag{6}$$

Let Hi denotes the prior probability for class S for individual i. Where Zi is a vector of segmentation variables consisting of recreation specialization; θ is a vector of parameters for segment s (s = 1, 2, . . , S).

Experimental Design

The service attributes with the subsequent levels were identified from literature review (Antonakos, 1994; Sener et al., 2009) and pilot test. The SP survey conducted in this research was designed to obtain information on recreational cyclist route preferences using a series of hypothetical route choice questions. For the SP experiments design, seven service attributes (i.e. bikeway length, bikeway type, bikeway slope, attraction, basic facility, reinforcement facility, and complete facility) of bicycle facility were chosen in this study. The attributes and their subsequent levels are shown in Table 1. Roadway grade was used to define as alternative specific constants (ASC). In this study, we used three route grades (Leisure, Endurance and Challenge) to estimate cyclists' preference, in order to understand cyclists' route grading preference in different experience. Roadway grades were classified according to roadway length and slope. The classifications of grades were shown in Table 2.

A total of 300 questionnaires were distributed during the period from November to December 2009. After eliminating the incomplete questionnaires, 232 useable responses were obtained yielding a 77.3% response rate. The questionnaire consists of three parts. Part 1 of the questionnaire deals with the measurement of recreational specialization with 16 items .More specifically, recreational specialization covers three dimensions, including behavior (i.e. past experience) with 5 items; cognitive (i.e. skill and Knowledge) with 5 items, and affective (i.e. enjoyment, important and centrality)with 6 items(Bricker et al. ,2000; Dyck et al. ,2003;McIntyre & Pigram ,1992). Part 2 deals with the choice experiment, according to the number of attributes and their associated levels, fractional factorial design was employed to reduce the number of choice sets to 16(see Table3). Each scenario contains three different grades (Leisure, Endurance and Challenge). Thus, 16 choice sets were randomly blocked into four versions. Each respondent was required to select one preferred alternative composed of various levels of service attributes. Finally, Part 3 reports respondents' demographic information with seven items, such as gender, age, marital status, occupation, personal monthly income, and education level via a categorical scale.

Table 1-Service Attributes and Subsequent Levels

Service attributes		Attributes levels	Variable name
roadway length		1. 5~15km 2. 20~30km 3. 40~50km	
roadway type		1. Bike path 2. Bike lane 3. Bike route	 BIKE LANE BIKE ROUTE
roadway slope		1. Flat (0-4%) 2. Some moderate hills (5-8%) 3. Some steep hills (9-12%)	
Attraction		1. Bikeway passes attraction 2. None	ATT
Supply facility	Basic facility	1. None 2. Toilet 3. Simple maintain equipment 4. Toilet & Simple maintain equipment	 BASF1 BASF2 BASF2
	Reinforcement facility	1. None 2. Bench 3. Tourist Information Center 4. Tourist Information Center & bench	 REINF1 REINF2 REINF3
	Complete facility	1. None 2. Restaurant service 3. Bicycle rental system 4. Restaurant service & bicycle rental system	 COMF1 COMF2 COMF3

Table 2- Roadway grade categories

Grade	Leisure	Endurance	Challenge
Roadway length	5~15km	50~70km	20~40km
Roadway slope	Flat (0-4%)	Some moderate hills (5-8%)	Some steep hills (9-12%)

Table 3-A sample of choice set

Attribute \ Route	A	B	C
Roadway length	5-15km	50-70km	20-40km
Roadway type	Bike path	Bike lane	Bike lane
Roadway slope	Flat (0-4%)	Some moderate hills (5-8%)	Some steep hills (9-12%)
Attraction	Roadway passes attraction	None	None
Basic facility	Toilet	Toilet & Simple maintain equipment	Simple maintain equipment
Reinforcement facility	None	None	Bench & Restaurant
Complete facility	Tourist Information Center & Bicycle rental system	Tourist Information Center	None
Option	□	□	□

EMPIRICAL RESULTS

Sample profile

The profile of the respondents showed that a larger proportion of respondents were males (67.7%) and married (56%). About 33.2% of the respondents were in the 29-39 age group, while 25.9% of the respondents belonged to the 40-50 group. Most respondents (57.3%) hold a university degree, while 36.3% have a monthly income between NT$20,001-40,000(US $625-1,250) and 19.4% were working with a commerce-related job, followed by 19.0% with a service job.

Multinomial logit model

Table 4 reports the coefficients of multinomial logit models under the assumption of homogeneity. The results of MNL model indicate that bikeway type, basic facilities of toilet and simple maintain equipment, attraction and tourist information center are statistically significant in preferences of bicycle facilities. The positive coefficient of basic facilities include toilet and simple maintain equipment, attraction, and tourist information center imply that cyclist are more likelihood of chosen bicycle route with these service facilities provided. The coefficient for bike route is negative in bikeway type, reflecting a significant preference for bike path. Moreover, the ASC are significant, indicating that cyclists prefer to use endurance route, and are unlikely to choice leisure route.

In addition, accounting for systematic heterogeneous by interactions of recreational specialization with facility attributes and ASC. MNL2 model results show that recreational cyclists who have frequent participation in cycling prefer bike route. Recreational cyclists who take long time in cycling are more likely to prefer restaurant service, and have lower cognitive recreational specialization are more likely to choice leisure route.

Table 4- Results of multinomial logit

	MNL1		MNL2	
Facility attributes	Coefficient(t value)	Standard error	Coefficient (t value)	Standard error
Leisure route	-0.45 (-4.84)**	0.09	-0.12(-0.84)	0.14
Endurance route	0.31(3.87**	0.08	0.26(2.03)*	0.13
BIKE LANE	-0.29(-2.66)**	0.10	-0.24(-1.77)	0.14
BIKE ROUTE	-0.84(-6.75)**	0.12	-1.08(-6.46)**	0.17
ATT	0.58(5.02)**	0.11	0.56(4.73)**	0.12
BASF1	0.08(0.53)	0.15	0.08(0.55)	0.16
BASF2	0.18(1.39)	0.17	0.19(1.40)	0.13
BASF3	0.32(2.43)*	0.13	0.36(3.32)**	0.11
REINF1	0.31(1.84)	0.17	0.32(1.88)	0.17
REINF2	0.43(2.70)**	0.16	0.44(2.72)**	0.16
REINF3	0.31(1.78)	0.17	0.31(1.73)	0.18
COMF1	0.03(0.26)	0.12	-0.25(-1.56)	0.17
COMF2	0.01(0.01)	0.14	-0.04(-0.26)	0.17
COMF3	0.12(0.95)	0.12	-0.08(-0.54)	0.16
Interactions				
FREQ*bike lane			-0.03(-0.17)	0.20
FREQ*bike route			0.50(2.14)*	0.23
TM*CF1			0.65(2.87)**	0.23
TM*CF2			0.06(0.25)	0.27
TM*CF3			0.45(1.92)	0.23

CO* Leisure route		-0.70(-3.36)**	0.20
CO* Endurance route		0.17(1.00)	0.17
AFF* Leisure route		-0.08(-0.44)	0.20
AFF* Endurance route		-0.04(-0.27)	0.17
LL(β)	-928.96	-908.31	
LL(0)	-981.19	-981.19	
ρ^2	0.05	0.07	

*p<0.05,**p<0.01

Latent Class model

A latent class model is estimated on respondents in the sample that are with recreational specialization and allow for testing latent heterogeneity in bicycle route. We estimated the latent class models without segmentation variables in the segment functions. Then, the minimum BIC and AIC are used to determine the optimal number of segments .Two, three, and four segment solutions are reported in Table 5. The result reveals that the number of segments increase, the AIC and BIC increase. The two segment have a lower AIC and BIC. Therefore, the two segment is selected to set up model.

The estimation results of LCM are reported in Table 6. The respondents are assigned to one of the segments in the basis of their largest probability score. The probabilities indicate that 56.7% of the respondents belong to segment 1 and 43.3% belong to segment 2. Segment 2 was used as a base, and the estimates of recreation specialization variables in segment 1 are interpreted as relative to segment 2. The results reveal that cyclists in segment 1 have more recreational specialization in cognitive dimension and invest money in bicycle equipment than segment 2; these cyclists are more likely to prefer endurance, challenge route, bike path, and attraction. Respondents in segment 2 prefer to choice leisure route, and are unlikely to choice endurance route. For segment 2, the coefficients of bicycle route facility attributes which included bike path, attraction, and full basic facilities, appear to have significantly positive effects on the utilities of choice.

Table 5- Criteria for determining the optimal number of segments

Number of class	Log likelihood value	AIC	BIC
2	-602.95	1263.9	1392.92
3	-600.2	1288.4	1484.15
4	-600.19	1318.38	1580.86

Table 6- Results of latent class models

Facility attributes	Segment 1		Segment 2	
	Coefficient (t value)	Standard error	Coefficient (t value)	Standard error
Utility functions				
Leisure route	-1.67(-4.52)**	0.37	0.25(2.33)**	0.11
Endurance route	0.54(3.75)**	0.15	-0.06(-0.50)	0.12
BIKE LANE	-0.58(-2.65)	0.22	-0.11(-0.83)	0.13
BIKE ROUTE	-0.83(-3.22)*	0.25	-1.22(-7.38)**	0.16
ATT	1.24(4.01)**	0.31	0.30(2.29)*	0.13
BASF1	0.10(0.34)	0.30	0.40(1.89)	0.21
BASF2	-0.30(-1.06)	0.28	0.87(4.78)**	0.18
BASF3	-0.11(-0.49)	0.22	0.91(6.00)**	0.15
REINF1	0.56(1.52)	0.37	-0.10(-0.53)	0.20
REINF2	0.95(2.79)	0.34	-0.15(-0.75)	0.19
REINF3	0.56(1.37)	0.41	-0.12(-0.59)	0.20
COMF1	-0.01(-0.05)	0.24	0.06(0.40)	0.15
COMF2	0.04(0.01)	0.29	-0.14(-0.86)	0.16
COMF3	0.47(1.68)	0.28	0.07(0.45)	0.15
Segment function				
Constant	-7.47(-3.14)**	2.45		
Cognitive	1.77(2.30)*	0.76		
Affective	0.42(0.92)	0.45		
money	0.39(3.80)**	0.10		
frequency	-0.08(-0.56)	0.15		
years	-0.29(-1.76)	0.17		
Class probability	56.7%		43.3%	
LL(β)	-892.37			

LL(0)	-981.18
ρ^2	0.13

CONCLUSIONS

This paper analyses recreational cyclists' preference for attributes of bicycle route facility in Taiwan. The SP method was conducted in which recreational cyclists were asked to state their choice from three unlabelled bicycle routes' alternatives on the basis of their attributes. Choice modeling was applied to the collected data and recreational cyclists' preferences for each attribute are estimated. This study used MNL model which include facility attributes and ASC interaction with recreational specialization dimensions; the model captures the systematic heterogeneity in recreational cyclists' preference. Subsequently, LCM is used to account for heterogeneity in the preference of bicycle route and facility attributes.

Empirical MNL results indicate that recreational cyclists prefer bicycle routes with attraction along the route, basic facilities including toilet and simple maintain equipment, tourist information center, and bike path. In addition, recreational cyclists who have frequent participation in cycling are more likely to prefer bike route. For the frequent recreational cyclist, bike route can provide diverse experience. Recreational cyclists who take long time in cycling are likely to prefer restaurant service, and low cognitive level in recreational specialization cyclists are more likely to choice leisure route.

Using LCM with segment membership functions for predicting segment membership of recreational cyclists, it allows for explicit identification of recreational specialization concept. Moreover, LCM also improves the model fit to the data, and allows for testing the impact of recreational specialization variable on segment membership. As a result, high recreational specialization cyclists are more likely than low recreational specialization cyclists to choice challenge and endurance grading route.

From a managerial perspective, bicycle route should be classified according to different group of recreational cyclist, for instance, riding experience, distance, slope, etc. In addition, base on safety conscious, roadway type is very important attribute to consider bicycle route. Bicycle path is separate from general roadway that cyclists can use exclusively route. It can improve safety considerations for barriers to bicycle use. From a long term perspective, increasing the number of recreational cyclists would contribute to efforts to increase the number of commuting cyclists.

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