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Students' Attitude Towards The Use Of Bicycle, Evidence From Kumamoto, Japan

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ABSTRACT : *Japan is a country with a large number of bicyclists, where 13% of people use bicycles for daily commuting and other personal affairs generally. Among all, student bicyclists constitute for the largest portion. This study analyzed the attitudes of high school students in Kumamoto, Japan towards the use of bicycle based on a survey of bicycle utilization in 2016. The purpose of this study is to explore the factors which influence the attitudes of students towards the use of bicycle in two different conditions: for school and for personal affairs. The approach of factor analysis and structural equation modeling are adopted in the procedure to estimate the different correlation between latent factors under these two conditions. According to results, there were 5 latent factors detected by the analysis, including attitude, sensitivity, convenience, safety and lifestyle. Under the condition of bicycling for schooling, latent factor convenience had the strongest with the attitude to using a bicycle, while both latent factors convenience and sensitivity had a strong correlation with attitude towards utilization of bicycles under the condition of bicycling for personal affairs.*

KEYWORDS *-bicycle, high school students, attitude, Structure Equation Model, latent factors*

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I. INTRODUCTION

Utilization of bicycle is much advocated in recent years. Many studies agree with that bicycle is not only an environment-friendly mode of transportation [1], regular bicycling has many health benefits to offer [2]. Apart from these benefits, scholars also attempt to increase the utilization of bicycle in the pursuit the sustainable transport system. Commuting, one of the purposes of riding a bicycle, has been discussed intensely. Biernat et al found that four types of bicycle commuters according to the motivations of riding a bicycle, and importance of the factors of car drivers' behavior and infrastructure quality has been recognized in Poland [3]. Several papers focused on the relationship between bicycle commuting and built environment found the existence of bicycle lanes can attract bicyclists to a neighborhood, but it does not encourage mode shift from automobile [4]. Many studies currently available focused on the children bicyclists and female bicyclists. For children and teens, safety has always been one of the most discussed topics. For example, Olofsson et al., suggests that the helmet use has a negative relationship with head injuries in children [5], whereas Anasahi found that factors such as distant trips and unsafe environment are some of barriers for female bicyclists to travel [6]. Currently, there are about 13% citizens as regular bicyclists in Japan. This is not a small number when compared to other developed countries. However, bicycling-related researches in Japan is still lacking.

The SEM (structure equation modeling) analysis is one of methodologies used in transport survey researches. It combines factor analysis and path analysis. In research area of social and behavior science, SEM can be used for the analysis of relationship between multi-variable and multi-result, and sometimes the unobservable latent variables. Li et al. used SEM to stimulate the relationship between 8 latent variables related to the attitude to bicycle commuting, and the latent variables were estimated from 29 questions in a questionnaire survey [1]. Similarly, Heredia et al. identified 4 latent variables and simulated the correlation between them. In the study, they found that factors of convenience and exogenous were more important than the factors of pro-bike and physical determinants when assessing users' intensions in riding a bicycle [7]. Before the application of SEM analysis, factor analysis such as exploratory factor analysis (EFA) or confirmatory factor analysis (CFA) is necessary. EFA is a technique used to find out the underlying structure of multivariate observational and measured variables. CFA tests whether the relationship between a factor and a corresponding

measure item satisfies the theoretical relationship designed by the researcher. In actual scientific research, the process of CFA is also the test of the measurement model and CFA is often tested by SEM. In research related to the process of CFA of transportation and behavior survey, the Theory of Planned Behavior (TPB) is one of most popular theories that are used as the conceptual framework. The TPB is a theory which links individual's beliefs and behavior, and states that attitude toward behavior, subjective norms, and perceived behavior control, together shape an individual's behavioral intentions and behaviors [8]. Heinen constructed the framework of psychological factors and the choice to commute by bicycle based on the TPB [9]. Anyway, current researches often prefer to apply other new theory in combination of TPB in the SEM. In Spain, researchers examined latent variables which affecting bicycle commuting based on the developed TPB survey and found seven latent variables [10].

The above research mentioned the research objectives and methodology in the past study related to bicycling behavior. This paper intended to focus on a special group of bicyclists, the high school student bicyclists in Japan. Japan charted at top 3 (13%) in the ranking of countries with largest population of citizens using bicycles in their daily life, just below Netherland (27%) and Denmark (19%) are the top 2 according to an international comparison study in 2010. Based on the 2012 Household Travel Survey (also called the PT survey) in Kumamoto Metropolitan area, students between 15 to 20 years old constitute the biggest group among all the different age groups of bicyclists [11]. Hence, it is obvious that student bicyclists in Japan are of great necessity to be analyzed. This study targeted on the high school students in Kumamoto, Japan and attempt to address the following questions: (1) what are the students' attitudes towards bicycling to school; (2) what are the students' attitudes towards bicycling during personal affairs; (3) what are the relationship and difference between the different attitudes under different conditions? (4) what variables would improve bicycle utilization among students? This paper is divided into 5 sections. In the next section, the case study survey, data collection and conceptual framework will be presented. The third section contains the part of methodology which interpreting the CFA and SEM. The fourth section discusses the latent variables which relating to attitudes towards utilization of bicycle under 2 conditions: bicycling for schooling and bicycling for personal affairs. Comparison between 2 conditions will also be conducted. The last section is the conclusion.

II. CASE STUDY AND SURVEY

Kumamoto city is a medium-size city in western Japan with a population of around 740,000 citizens. There were a total of 370,490 bicycles in the city in 2013. According to the national household travel survey in 2010, the general proportion of bicycle utilization in Japan was 13% while Kumamoto City is above 20%. Students, especially high school and university students ride bicycles commonly. This study focused on the high school student in which a questionnaire survey data on high school students' attitudes towards bicycle was employed. A total of 21 classes in grade 2 from 21 high schools had participated into the survey: 8 of the classes are from public school, while the remaining 13 are from private school; 10 of them are from vocational high school, while the remaining 11 are from normal high school. At last, 806 questionnaires were collected. This survey was divided into several parts including questions regarding bicycling to school (Table 1), bicycling for personal affairs (Table 2), and traffic accident experience, awareness of traffic rules, bicycle parking, bicycle policies and personal demographic information.

Table 1 Questionnaire of attitudes towards bicycle under the condition of bicycling for schooling

Q1. Distance: how long is it from your home to school?
Q2. Time 1: what time do you leave home in the morning?
Q3. Time 2: how long do you spend on the trip to school?
Q4. Economic: will you choose bicycling to school because it saves money?
Q5. Speed: will you choose bicycling to school because it saves time?
Q6. Flexibility: will you choose bicycling to school because it is easy to move by oneself?
Q7. Marks: do you think the bicycle related marks on the road will attract you ride a bicycle more?
Q8. Facility 1: do you think the bicycle lane to transportation facilities will attract you ride a bicycle more?
Q9. Facility 2: do you think the bicycle lane on roadway will attract you ride a bicycle more?
Q10. Facility 3: do you think the bicycle lane on sidewalks will attract you ride a bicycle more?
Q11. Accident 1: do you have any experience of a traffic accident?
Q12. Accident 2: do you have any experience where you almost meet a traffic accident?
Q13. Manner: do you think the improvement of drivers' manner will attract you ride a bicycle more?
Q14. Barrier: do you think decreasing barriers (such as parking on the sidewalk or roadway) will attract you ride a bicycle more?
Q15. Comfort: will you ride a bicycle to school because you enjoy bicycling?
Q16. Health: will you ride a bicycle to school because it is good for health?
Q17. Environment: will you ride a bicycle to school because it benefits the environment?
Q18. Awareness: will you ride a bicycle to school because your classmates usually ride a bicycle?
Q19. Willingness: do you ride a bicycle to school?
Q20. Frequency: how often do you ride a bicycle?

Table 2 Questionnaire of attitudes towards bicycle under the condition of bicycling for personal affairs

Q1. Time 1： when do you ride a bicycle for personal affairs?
Q2. Time 2: how long will you spent for the personal affairs?
Q3. Economic: will you choose bicycling to school because it saves money?
Q4. Speed: will you choose bicycling to school because it saves time?
Q5. Flexibility: will you choose bicycling to school because it is easy to move by oneself?
Q6. Parking 1: do you think the parking space on destination for bicycles will attract you ride a bicycle more?
Q7. Marks: do you think the bicycle related marks on the road will attract you ride a bicycle more?
Q8. Parking 2: Q8, do you think parking space on transportation facilities for bicycles will attract you ride a bicycle more?
Q9. Facility 1: do you think the bicycle lane to transportation facilities will attract you ride a bicycle more?
Q10. Facility 2: do you think the bicycle lane on roadway will attract you ride a bicycle more?
Q11. Facility 3: do you think the bicycle lane on sidewalks will attract you ride a bicycle more?
Q12. Accident : do you have any experience of a traffic accident?
Q13. Accident 2: do you have any experience where you almost meet a traffic accident?
Q14. Manner: do you think the improvement of drivers' manner will attract you ride a bicycle more?
Q15. Barrier: do you think decreasing barriers (such as parking on the sidewalk or roadway) will attract you ride a bicycle more?
Q16. Comfort: will you ride a bicycle to school because you enjoy bicycling?
Q17. Health: will you ride a bicycle to school because it is good for health?
Q18. Environment: will you ride a bicycle to school because it benefits the environment?
Q19. Awareness: will you ride a bicycle to school because your classmates usually ride a bicycle?
Q20. Willingness 1: do you ride a bicycle to go shopping (within 3km)?
Q21. Willingness 2: do you ride a bicycle to go for social activities (within 3km)?

III. METHODOLOGY

The research procedure of this study can be categorized into 3 parts using different approaches. In addition to the questionnaire survey data, other information derived from non-questionnaire data source which includes the social-demographic information, related urban built environment information and location information of the 21 high schools are firstly analyzed. Next, factor analysis which includes both exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) are employed to identify the latent variables. Following that, the relationship between these latent variables is simulated by SEM. Lastly, a comparison analysis is conducted under 2 conditions: bicycling for schooling or bicycling for personal affairs.

3.1. DATA SOURCE

Firstly, indicators related to the attitudes in the questionnaire towards bicycling for schooling and personal affairs are classified. Non-questionnaire data are obtained from the national population census survey and urban built environment survey of Kumamoto City in 2012. This includes the social-demographic information of Kumamoto City, especially the areas where the high school students live in and the location information of every high school, which are the destinations for bicycling trips for schooling. These data are presented and analyzed by ArcGIS.

3.2. FACTOR ANALYSIS

As the questionnaire concludes various parts related to bicycle utilization, the authors will first apply an EFA analysis to classify the indicators into group before finding out the possible latent variables. Next, correlation analysis between all the factors is carried out to detect the useful factors for measurement model in SEM. Those variables which do not have correlation with each other or contribute little to the estimation of latent variables are then deleted.

3.3. SEM STRUCTURE

The authors conducted SEM twice using SPSS Amos 21 with 2 models under 2 types of condition. Under the condition of bicycling for schooling, there are 5 latent variables and 20 indicators; whereas under the condition of bicycling for personal affairs, there are 5 latent variables and 21 indicators. Latent variables in this study includes attitude, sensitivity, convenience, safety and lifestyle.

IV. RESULT AND DISCUSSION

4.1. SOCIAL-DEMOGRAPHIC AND BUILT ENVIRONMENT INFORMATION

The results of three descriptive statistics will be discussed in this part. The first part is bicycling for schooling; while the other two parts are for the purpose of personal affairs, including shopping and social activities.

According to Table 3, it is obvious that there are more male bicyclists compared to female bicyclists among the group of high school students. Since the survey group are students from the same grade (Grade 2), there is little age difference between bicyclists and non-bicyclists. Nevertheless, it is important to note that the

number of bicyclists in private both and public high school is higher than the number of non-bicyclists. Hence, we can conclude that bicycle is a main mode of transportation tools for schooling among high school students. When compared to vocational high school, it is found that students in normal high school are more likely to cycle to school. Comprehensively, male students in normal private high school is the biggest group of bicyclists. The average distance of bicycling to school is 6.2km, which is nearly half of the average commuting distance of non-bicyclists. Correspondingly, bicyclists spent less time on their trips to school and the average departure time

Table 3Descriptive statistics of samples under the condition of bicycling for schooling

	Bicyclists (n=596)		Non-bicyclists (n=210)		Full sample (n=806)		
	Mean	SD	Mean	SD	Mean	SD	Variable description
Socio-demographic characteristic							
Gender	0.56		0.34		0.503		0=Female; 1=Male
Age	16.33	0.96	16.35	0.91	16.336	0.946	Continuous
School type 1	0.38		0.43		0.393		0=Private school; 1=Public school
School type 2	0.55		0.48		0.527		0=Vocational school; 1=Normal school
Schooling trip characteristic							
Distance of trip	6.20	4.91	10.99	7.83	6.57	5.35	Continuous
Departure time	7.12	0.64	6.84	0.60	7.09	0.64	Hours; Continuous
Time of trip	32.01	17.65	41.21	26.57	32.79	18.73	Minutes; Continuous
Built environment characteristic							
Population density(origin)	3206.41	2645.07	3041.09	2906.74	3164.11	2713.441	Continuous
Road length(destination)	12671.09	1877.08	12936.17	1694.77	12740.16	1833.997	Continuous; total road length of destination with 500m buffer
Road slope of destination	0.02	0.01	0.02	0.02	0.02	0.01	Continuous; average slope of destination in 500m buffer

is also later than non-bicyclists. From the perspective of built environment factors, students whose family are in neighborhood with higher density of population has a higher likelihood to ride a bicycle. It is also observed that there is little to no influence of road density and terrain of destination on the divergence between bicyclists and non-bicyclists.

Table 4 and 5 show the descriptive statistics under the condition of bicycling for shopping and social activities. The survey in this part divides the distance for personal affairs into 3 sections: distance<3km; 3km<distance<10km; 10km<distance. With the increasing of trip distances, the number of bicyclists is decreasing sharply in both shopping and social activities. It is obvious that bicycling within short distance is more expectable than longer distance. Specific to gender difference, male students are more likely to cycle for shopping or social activities compared to female bicyclists, and as the distance increases, this trend becomes even more pronounced. This result shows that male bicyclists have the physical advantage over female bicyclists on the long-distance bicycling trip. Although there is little difference in age, we could still find the average age is increasing with the distance. As for the school types, the number of bicyclists in private school are more than that in public school, but the proportion of bicyclists in public school are increasing in long distance trips for personal affairs.

Since the type of school could reflect the statues of family income to a certain degree, it is understandable that students in public school are more likely to ride in long-distance trip to avoid any possible transportation costs. On the other hand, students in normal high school are more willing to ride a bicycle for shopping as well as social activities compared to students in vocational high school.

Table 4Descriptive statistics of samples under the condition of bicycling for personal affairs (shopping)

	<3km Bicyclists (n=604)		Non-bicyclists (n=190)		3-10km Bicyclists (n=464)		Non-bicyclists (n=329)		>10km Bicyclists (n=169)		Non-bicyclists (n=616)		
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Variable description
Gender	0.58		0.28		0.66		0.29		0.82		0.42		0=Female; 1=Male
Age	16.32	0.94	16.36	0.97	16.36	0.91	16.30	0.98	16.51	0.90	16.29	0.95	Continuous
School type 1	0.38		0.45		0.39		0.40		0.41		0.39		0=Private school; 1=Public school
School type 2	0.53		0.52		0.55		0.50		0.60		0.52		0=Vocational school; 1=Normal school
Population density of origin	3198.06	2667.42	3085.33	2859.54	3272.12	2744.32	3016.21	2660.61	3396.96	2817.67	3103.12	2674.80	Continuous (people/km²)
Departure time	14.03	3.00	12.74	3.35	13.91	3.04	14.09	3.05	13.28	3.15	14.22	2.95	Hours; Continuous
Variation of time	2.16	2.50	2.12	2.84	2.29	2.61	1.87	2.27	2.38	2.64	2.09	2.46	Hours; Continuous

Table 5Descriptive statistics of samples under the condition of bicycling for personal affairs (social activities)

	<3km Bicyclists (n=575)		Non-bicyclists (n=155)		3-10km Bicyclists (n=454)		Non-bicyclists (n=275)		>10km Bicyclists (n=215)		Non-bicyclists (n=510)		
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Variable description
Gender	0.59		0.32		0.65		0.34		0.79		0.43		0=Female; 1=Male
Age	16.34	0.93	16.44	0.99	16.39	0.48	16.32	0.96	16.53	0.88	16.30	0.96	Continuous
School type 1	0.35		0.41		0.36		0.37		0.41		0.39		0=Private school; 1=Public school
School type 2	0.56		0.50		0.56		0.52		0.60		0.52		0=Vocational school; 1=Normal school
Population density of origin	3216.62	2688.07	2979.04	2784.18	3173.68	2679.97	33124.10	2765.08	3366.91	2747.45	3059.25	2682.68	Continuous (people/km²)
Departure time	13.97	3.04	13.65	3.01	13.85	3.07	14.16	2.94	13.58	3.06	14.19	2.99	Hours; Continuous
Variation of time	2.27	2.59	1.61	2.09	2.39	2.63	1.73	2.25	2.57	2.77	2.00	2.39	Hours; Continuous

Table 6Correlations among factors under the condition of bicycling for schooling

Correlations	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1. Distance	1.00																			
2. Time 1	**-0.26**	1.00																		
3. Time 2	**0.53**	**-0.43**	1.00																	
4. Economic	0.10	**0.28**	0.09	1.00																
5. Speed	**-0.22**	**0.42**	-0.19	0.06	1.00															
6. Flexibility	0.00	**0.25**	0.00	0.14	0.05	1.00														
7. Marks	-0.05	**0.20**	-0.05	0.14	0.11	0.18	1.00													
8. Facility 1	-0.01	0.17	0.00	0.14	0.15	0.14	0.21	1.00												
9. Facility 2	-0.09	**0.43**	-0.13	**0.23**	**0.26**	**0.24**	**0.31**	**0.24**	1.00											
10. Facility 3	0.02	**0.28**	0.03	**0.25**	0.16	0.18	**0.31**	0.17	**0.29**	1.00										
11. Accident 1	0.02	0.13	-0.02	0.01	0.03	0.10	0.02	0.01	0.07	0.00	1.00									
12. Accident 2	0.05	**0.21**	0.03	0.16	0.11	0.09	0.08	0.07	0.10	0.15	-0.16	1.00								
13. Manner	-0.02	0.19	-0.01	0.10	0.13	0.12	**0.24**	**0.29**	**0.22**	**0.23**	0.06	0.10	1.00							
14. Barrier	-0.01	0.16	-0.04	0.12	0.07	**0.22**	**0.36**	**0.30**	**0.22**	**0.25**	0.11	0.05	**0.45**	1.00						
15. Comfort	0.03	0.13	-0.04	0.14	0.14	0.16	0.16	0.10	0.15	0.11	0.06	0.04	0.07	0.09	1.00					
16. Health	0.09	0.19	0.01	**0.20**	0.11	**0.21**	0.11	0.12	**0.21**	0.12	0.03	0.06	0.12	0.09	**0.21**	1.00				
17. Environment	-0.06	0.12	-0.06	0.12	0.10	0.12	0.09	0.07	0.03	0.08	-0.02	0.01	0.06	0.05	0.18	**0.33**	1.00			
18. Awareness	0.05	**0.29**	-0.02	0.07	0.16	0.17	0.15	0.09	**0.27**	0.15	0.11	0.03	0.10	0.11	0.03	0.08	0.05	1.00		
19. Willingness	**-0.24**	**0.80**	-0.14	**0.31**	**0.48**	**0.32**	**0.24**	**0.23**	**0.55**	**0.34**	0.15	**0.21**	**0.24**	**0.21**	0.15	**0.24**	0.14	**0.38**	1.00	
20. Frequency	**-0.25**	**0.65**	-0.16	**0.25**	**0.38**	**0.25**	**0.21**	0.17	**0.46**	**0.29**	0.10	**0.20**	0.18	0.19	0.09	0.14	0.11	**0.37**	**0.75**	1.00

Table 7Correlations among factors under the condition of bicycling for personal affairs

Correlations	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1. Time 1	1.00																				
2. Time 2	-0.13	1.00																			
3. Economic	-0.03	0.07	1.00																		
4. Speed	0.07	0.00	0.04	1.00																	
5. Flexibility	0.03	0.10	0.13	0.11	1.00																
6. Parking 1	-0.04	0.03	0.10	**0.33**	0.15	1.00															
7. Marks	0.05	0.06	0.11	0.16	0.14	0.07	1.00														
8. Parking 2	-0.04	0.06	-0.03	0.06	0.06	**0.30**	0.18	1.00													
9. Facility 1	-0.01	0.02	0.12	**0.33**	0.12	**0.64**	0.14	**0.31**	1.00												
10. Facility 2	-0.06	0.03	0.09	**0.21**	0.14	**0.64**	0.08	0.13	**0.63**	1.00											
11. Facility 3	-0.04	-0.01	0.09	**0.24**	0.13	**0.66**	0.07	0.19	**0.65**	0.78	1.00										
12. Accident 1	-0.01	0.05	0.01	0.03	0.07	0.02	-0.01	0.03	-0.01	0.02	-0.01	1.00									
13. Accident 2	0.04	0.08	0.15	0.17	0.10	0.18	0.13	-0.02	0.13	0.12	0.13	-0.16	1.00								
14. Manner	-0.07	0.01	0.10	**0.24**	0.11	**0.62**	0.16	0.16	**0.60**	**0.63**	**0.61**	-0.01	0.11	1.00							
15. Barrier	-0.04	-0.01	0.07	**0.32**	0.15	**0.51**	0.10	**0.23**	**0.48**	**0.50**	**0.50**	0.02	0.10	**0.56**	1.00						
16. Comfort	0.05	0.04	0.15	0.10	**0.21**	0.06	0.11	0.08	0.11	0.03	0.05	0.09	0.04	0.08	0.10	1.00					
17. Health	0.06	0.05	**0.23**	0.08	**0.22**	0.07	0.14	0.04	0.14	0.08	0.11	0.03	0.07	0.12	0.08	**0.32**	1.00				
18. Environment	0.04	0.05	**0.23**	0.04	0.12	0.11	0.14	0.15	0.14	0.11	0.12	0.01	0.04	0.10	0.11	**0.34**	**0.37**	1.00			
19. Awareness	-0.09	0.03	0.08	0.17	0.14	**0.20**	0.19	0.03	0.19	**0.23**	0.17	0.09	0.03	0.18	**0.23**	0.00	0.05	0.05	1.00		
20. Willingness 1	0.08	0.00	**0.25**	**0.51**	**0.25**	**0.63**	0.09	0.11	**0.58**	**0.55**	**0.55**	0.09	**0.22**	**0.51**	**0.45**	0.11	0.14	0.12	**0.33**	1.00	
21. Willingness 2	0.03	0.08	0.15	**0.27**	0.11	**0.32**	0.14	0.02	**0.30**	**0.28**	**0.26**	0.05	0.11	**0.24**	**0.26**	0.07	0.10	0.03	**0.28**	**0.49**	1.00

4.2. LATENT FACTORS IDENTIFIED BY FACTOR ANALYSIS

Authors have classified the variables into groups and detect a series of latent factors after the analysis of questionnaire on the attitudes of high school students towards the use of bicycles. Since the questionnaire is divided according to two cycling conditions: one for schooling; and another for personal affairs, 5 latent factors are extracted from the variables under these 2 conditions which are sensitivity, convenience, safety, lifestyle and attitude.

Sensitivity: this latent factor measures the distance, time and economic variables related to travel needs. The distance between school and home, the time of departure to school, time spent on the trip or the economic cost of the trip may easily influence the decision of whether to use the bicycle as the main transportation tool. Under the condition of bicycling for schooling, trip distance (Q1), departure time (Q2), time spent on the trip to school (Q3) and economic concern (Q4) are related to this latent factor (Table 6); under the condition of bicycling for personal affairs, departure time (Q1), time spent on the trip for personal affairs (Q2) and economic concern (Q3) are related to this latent factor (Table 7). Variables related to distance are not included in the condition of bicycling for personal affair because the authors have defined distance below 3km as the foundation of this cycling condition in second part of questionnaire.

Convenience: this latent factor measures characteristics which improve the quality of trips, for example, the efficiency and flexibility when compared with other transportation modes. Efficiency means the preference on bicycle because students think speed is an important factor when they consider riding a bicycle to school. Flexibility means a comparatively free characteristic of a bicycle where it can be easily handled or moved around by oneself. In addition, bicycle-related road markings and signs are also thought to be contributing to the convenience factor. Since the parking facilities are generally offered by schools, this variable on parking facility is only considered in the second condition where students must find a place to park their bicycles when they cycle for shopping or social activities. In short, under the condition of bicycling for schooling, speed and efficiency (Q5), flexibility(Q6) and bicycle-related road markings and signs (Q7) describe this latent factor (Table 6); under the condition of bicycling for personal affairs, the related variables are: the speed and efficiency (Q4), flexibility(Q5), parking facilities in the destination (Q6), and parking facilities in public transport service, for example, JR railway stations and bus stops (Q8) (Table 7);.

Safety: this latent factor measures important factors which influence the safety statement of student to decide whether to ride a bicycle or not. Variables mainly divided into 3 sections. Variables in the first section are detected from the students themselves, whether they had experienced traffic accidents, or whether they had experienced near-miss traffic accidents. The correlation between the variable of real experience with traffic accidents and the latent factor of safety is rather weak compared to the variable of near experience with traffic accidents under both conditions. Hence, only the latter variable is considered in the next part of SEM. Variables in the second sections are related to bicycle-related facilities, for example, bicycle lane on the sidewalks, bicycle lane on the roadways and barriers such as parked automobiles on the roadside. The last section is the variable of necessity of improving road manners of automobile drivers which also influences the feeling of safety in the bicyclists. Under the condition of bicycling for schooling, bicycle lanes to public transportation service facilities(Q8), bicycle lanes on roadways (Q9), bicycle lanes on sidewalks (Q10), almost having an experience of traffic accident (Q12), road manner of drivers (Q13) and barriers on the roadside (Q14) describe the latent

factor of safety (Table 6); under the condition of bicycling for personal affairs, bicycle lane to transportation facilities (Q9), bicycle lane on roadways (Q10), bicycle lane on sidewalks (Q11), almost having an experience of traffic accidents (Q13), road manner of drivers (Q14) and barriers on the roadside (Q15) describe the latent factor of safety (Table 7).

Lifestyle: this latent factor measures the benefits of bicycling habit in the bicyclists. Variables like enjoyment of riding a bicycle, health benefits, and eco-friendliness which make students prefer to ride a bicycle are considered here. However, there are little correlation observed between students who ride a bicycle in daily life and the variable of eco-friendliness. Hence, this variable is excluded from the SEM analysis. In addition, awareness of riding a bicycle which influenced by peer pressure is also a useful variable. All these factors are tested in the factor analysis and correlation analysis, different variables are used to describe the latent factor of lifestyle in this part. Under the condition of bicycling for schooling, variables like enjoying riding a bicycle (Q15), good for health (Q16) and awareness influenced by classmates (Q18) describe the latent factor of lifestyle (Table 6). Under the condition of bicycling for personal affairs, differently, only variable of awareness influenced by classmates (Q19) efficiently describe the latent factor of lifestyle (Table 7).

Attitude: the most important latent factor in this study states the preference of riding bicycle among students by measuring the variables of bicycle usage and frequency of riding a bicycle. Under the condition of bicycling for schooling, riding bicycle to school or not (Q19) and frequency of riding a bicycle in a week (Q20) are the variables to describe the latent factor of attitude (Table 6). Under the condition of bicycling for personal affairs, willingness to ride a bicycle for shopping within 3km (Q20) and willingness to ride a bicycle for social activities within 3km (Q21) are the variables to describe the latent factor of attitude (Table 7).

4.3. Estimating correlations between variables under the condition of bicycling for schooling

The structure of model using SEM under the condition of bicycling for schooling is shown in Fig 1. The assessment of goodness of fit of the model is based on the comparative fit index (CFI), the root mean square error of approximation (RMSEA), the Chi-square test, the goodness of fit index (GFI) and the adjusted goodness of fit index (AGFI) by SPSS Amos21. Comparative fit index (CFI)= 0.921>0.900, the root mean square error of approximation (RMSEA) = 0.053, Chi-square is 459.623 with p-value=0.000<0.05, the goodness of fit index (GFI)=0.944>0.900 and the adjusted goodness of fit index (AGFI) =0.924> 0.800 demonstrate that the model of SEM under this condition meet the necessary requirements and is a good fit. Correlation between latent factors are shown in the Fig 1.

4.3.1. Attitudes

Fig.1 demonstrates that latent factor attitudes can describe 77.2% of willingness to ride a bicycle and 96.2% of frequency of riding a bicycle under the condition of bicycling for schooling. Obviously, latent factor convenience has a strong and positive correlation with attitudes and a normal correlation with safety. Both latent factors of sensitivity and flexibility have a normal and positive correlation with the latent factor attitude.

4.3.2. Sensitivity

The results show that the latent factor sensitivity can interpret 97.3% of the departure time variables and 54.7% of trip time variables. Whereas only 40.6% of the trip distance and 30.2% of economic can be explained by the factor of sensitivity. However, sensitivity is not the most crucial factor in the influence of attitudes towards the use of bicycle for schooling.

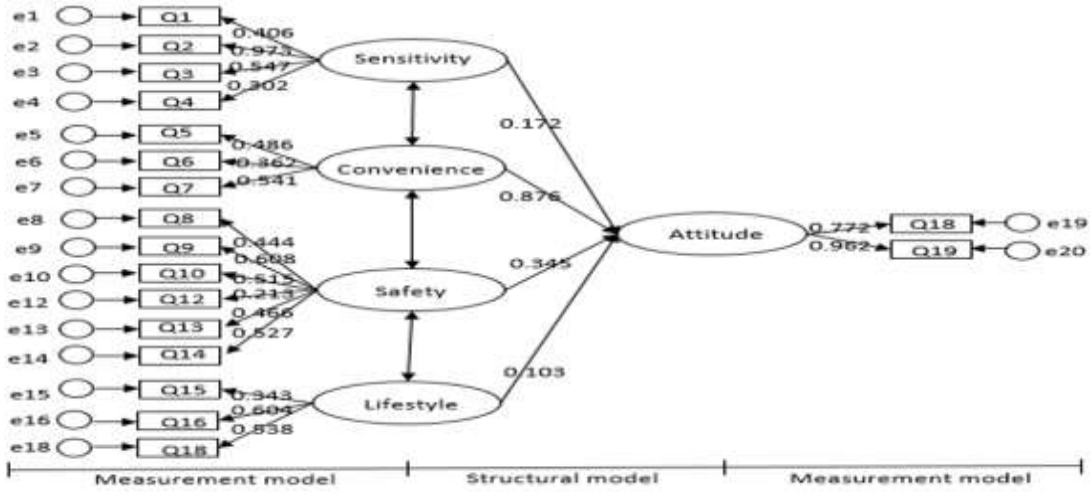

Fig.1 Estimation results of SEM model under the condition of bicycling for schooling

4.3.3. CONVENIENCE

Fig.1 that the convenience latent factor explains the most (87.6%) of the attitudes towards the use of a bicycle for schooling. The convenience latent factor can interpret 54.1% of the importance of bicycle related road signs and markings, 48.6% of efficiency needs and 36.2% of the importance of flexibility. In the authors' opinion, well-maintained traffic markings and signs are commonly available around school areas and they are useful for the students to ride to school. In addition, efficiency and flexibility are also positive variables described by convenience.

4.3.4. SAFETY

Latent factor safety is a normal indicator to the latent factor attitude. Concern on safety issues will decrease the willingness of students to ride a bicycle to school. Latent factor safety explains the importance of bicycle related facilities: 44.4% of bicycle lane around the public transport hub, 60.8% of bicycle lane on roadway and 51.5% of bicycle lane on sidewalks. In addition, 21.3% of experience of almost having a traffic accident can be interpreted by this latent factor. Besides, latent factor safety also explains 46.6% of necessity of improving road manner of automobile drivers and 52.7% of existence of barrier on the roadsides.

4.3.5 LIFESTYLE

The last latent factor lifestyle only explains 10.3% of the latent factor attitudes, which is not a high impact. 34.3% of enjoying riding a bicycle, 60.4% of concern about health improvement and 53.8% of awareness influenced by classmates are variables described by this latent factor.

4.4. ESTIMATING CORRELATIONS BETWEEN VARIABLES UNDER THE CONDITION OF BICYCLING FOR PERSONAL AFFAIRS

The structure of model using SEM under the condition of bicycling for personal affairs is shown in Fig.2. The assessment of goodness of fit of the model is based on the comparative fit index (CFI), the root mean square error of approximation (RMSEA), the Chi-square test, the goodness of fit index (GFI) and the adjusted goodness of fit index (AGFI) by SPSS Amos21. Comparative fit index (CFI)= 0.903>0.900, the root mean square error of approximation (RMSEA) = 0.083, Chi-square is 555.529 with p-value=0.000<0.05, the goodness of fit index (GFI)=0.911>0.900 and the adjusted goodness of fit index (AGFI) =0.874> 0.800 demonstrate that the model of SEM under this condition meet the necessary requirements and is a good fit.

4.4.1. ATTITUDES

The SEM structure presents correlation between 5 latent factors. First, both latent factor sensitivity and convenience describe 77.2% and 69.9% of latent factor attitude, respectively. At the same time, latent factor safety has a normal correlation with attitude and interpret 34% of it. Latent factor attitude describes 91.3% of willingness to ride a bicycle for shopping and 49.5% of willingness to ride a bicycle for social activities.

4.4.2. SENSITIVITY

Variable of departure time is one of the most important variables in which 83.5% can be explained by latent factor sensitivity. Besides, this latent factor can interpret 38.5% of time spent for personal affairs and 31.3% of economic variable.

4.4.3. CONVENIENCE

Under the condition of bicycling for personal affairs, the issue on parking facilities for bicycles is also included in the questionnaire survey. Authors find that the existence of parking facilities, especially those in the destination of possible trips for shopping and social activities such as shopping mall or downtown area, are principal factor in improving the convenience of bicycling for personal affairs. In addition, this latent factor can explain 36.1% of preference on parking facilities in public transport hub such as JR railway stations or bus stops. On the other hand, 39.5% of efficiency and 18.7% of flexibility can be explained by this latent factor.

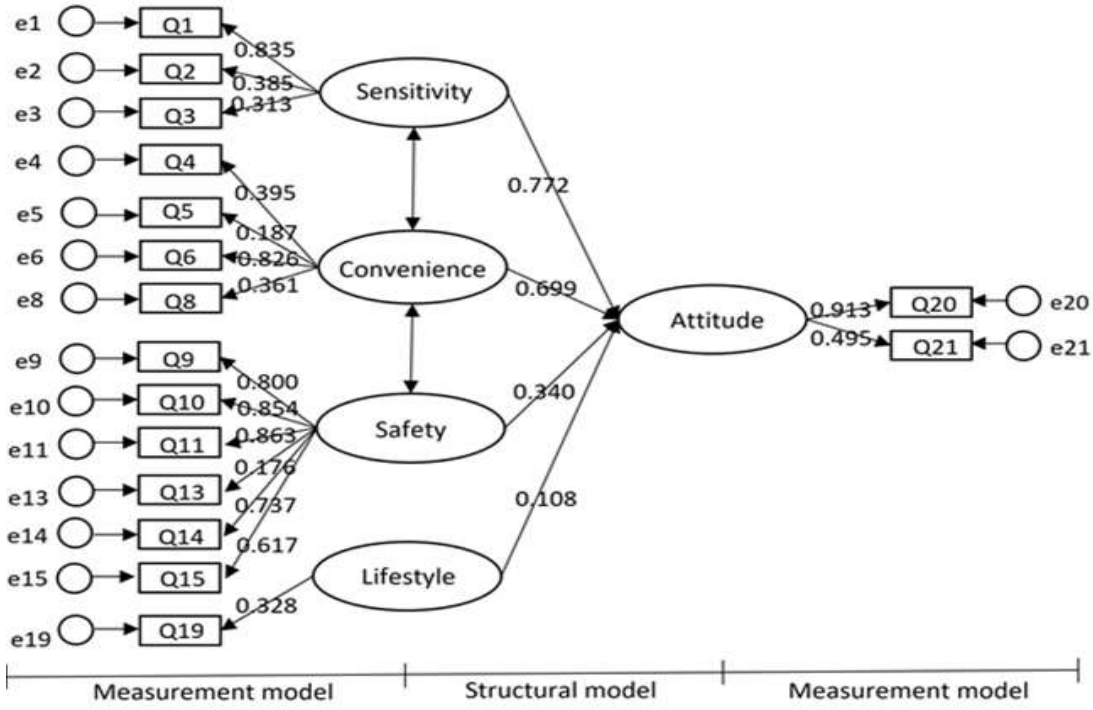

Fig.2Estimation results of SEM model under the condition of bicycling for personal affairs

4.4.4. SAFETY

Three variables regarding of road facilities have a strong correlation with the latent variable safety, which can explain 80% of variable of bicycle lane near public transport hub, 85.4% of bicycle lane on roadways and 86.3% of bicycle lane on sidewalks. The results imply that students have a strong preference on the use of bicycle lane. In addition, 73.7% of improving automobile drivers' road manner and 61.7% of variable of decreasing barriers on the road can also be explained by latent factor safety. Unexpectedly, previous experience with traffic accidents has no correlation with safety, and there is only 17.6% variable of experience of near-miss traffic accidents can be interpreted by this latent factor.

4.4.5. LIFESTYLE

Lifestyle latent factor has a week correlation with latent factor attitudes latent factor. 32.8% variable of awareness influenced by classmates can be explained by latent factor lifestyle latent factor.

V. CONCLUSION

This study analyzed the students' attitudes towards the utilization of bicycle for schooling and for personal affairs by factors analysis and SEM. Five latent factors: attitude, sensitivity, convenience, safety and lifestyle are detected, and their correlation are analyzed by SEM. According to SEM, there are different explanation for correlation between attitudes and other 4 latent factors under 2 conditions: bicycling for school and for personal affairs.

For the latent factor sensitivity, it is obvious that its correlation with latent factor attitude is stronger

under the condition of bicycling for personal affairs than for schooling. This is because the time to leave home for schooling usually has a short and fixed range. As a result, the time variables do not reflect the sensitivity latent factor well under this condition. Whereas for the latent factor convenience, there is a strong correlation with latent factor attitude under both conditions. However, some differences in certain specific variables are noticed. For example, under the condition of bicycling for personal affairs, authors find that the variable of flexibility is less important to the latent factor of convenience. This is because personal affairs discussed in this study include shopping and social activities which always happens with a group of people, hence, it is difficult to achieve flexibility when one is with a group people. In addition, improvement of parking facilities for bicycles is of great importance, especially the parking space in downtown area and shopping malls. For the latent factor safety, preference on increasing bicycle lane, improvement of automobiles drivers' manner, decreasing barriers on roadside can be explained very well by this latent factor. Besides, the study found that students prefer to ride on a bicycle lane more under the condition for personal affairs. However, it is surprising that the previous experience with traffic accidents cannot be described well with latent factor safety. This might be due to the factor that the experience of real traffic accident is rare and thus the data is not enough to construct a clear correlation with the latent factor safety. Meanwhile for the last latent factor, lifestyle, the variables for both conditions are entirely similar, however, both have shown weak correlation with latent factor attitudes. This study also observed that students' attitudes towards bicycle utilization are generally influenced by their classmates' preferences.

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