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TRANSITION TO A CYCLABLE CITY: POLICIES AND VARIABLES AFFECTING CYCLING COMMUTING

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ABSTRACT

The growing interest in achieving the objectives of cycling policies has increased the need to know the key variables that influence the use of the bicycle for daily mobility. This paper makes a contribution in this research line by examining a varying nature of variables – objective and psychological - and their influence on cycling commuting in the context of a "climber cycling city": Vitoria-Gasteiz (Spain). Statistical differences of the variables were determined between cycling commuters and commuters by other modes. The objective variables analyzed allowed us to identify the cycling commuting profile in Vitoria-Gasteiz, but showed a small effect on cycling commuting. However, analyses on seven cycling psychological variables identified and defined, showed a higher influence, especially "*Individual capacities"* and "*Non-commuting cycling habit*". Their results allowed recommending a wide set of policy initiatives. These policy recommendations were made considering that Vitoria-Gasteiz is a "city in transition" towards cycling: a high level of cycling share for the Spanish context and the safety issue not being the main barrier for cycling. However the psychological latent variable "*Non-commuting cycling habit*" indicates that normalization of the bicycle as a mode of transport needs more progress.

1 INTRODUCTION

Sustainability problems related to urban transportation are long and widely known in developed countries. Public policies to reduce them have mainly focused on promoting public transportation and non-motorized modes. This is the case of cycling, with policy documents such as the Green Paper on Urban Mobility (European Commission, 2007). In the Spanish case, with the objective of increasing the bicycle share, many cities have developed bicycle mobility plans in the last decade, and have already started implementing their corresponding measures. Despite remarkable recent increases in cycling demand (Monzon and Rondinella, 2010) Spanish cycling levels are still far from those in other European countries. In addition, since the bicycle is not considered as a real mode of transportation in many cities, it is not included in mobility household surveys. Therefore, in Spain, the lack of information about the bicycle as a mode of transportation is another problem.

The growing interest in achieving the objectives of cycling policies has increased the need to know the key variables that influence the use of the bicycle for daily mobility. Both policy-makers´ projects and academic research are recently increasing efforts to answer this research question. Traditional variables such as time and cost do not sufficiently explain the choice of the bicycle as a mode of transportation, and a wide array of variables are being studied, including psychological variables. The latest are perceptions or personal valuations of specific aspects which most of the time do not have an equivalent in the objective space and that cannot be directly measured. This type of variables have recently been identified by literature as influential in the decision to commute by bicycle (Stinson and Bhat, 2004; de Bourdeaudhuij et al., 2005; De Brujin et al., 2005; Moudon, 2005; De Geus et al., 2007; Dill and Voros, 2007; Gatersleben and Appleton, 2007; Titze et al., 2008; Akar and Clifton, 2009; De Brujin et al., 2009; Handy et al., 2010; Panter et al., 2010; Xing et al., 2010; Eriksson and Foward, 2011; Heinen et al., 2011; Lee et al., 2011; Heinen and Handy, 2012; Fernandez-Heredia et al., submitted for publication; Munoz et al., 2013; Sigurdardottir et al., 2013).

Empirical research on the varying nature and the complexity of the variables that affects cycling commuting constitutes an active research field (Heinen et al., 2010). This paper makes a contribution in this research line, with a more comprehensive approach to the investigation of variables influencing cycling commuting in the case study of Vitoria-Gasteiz (Spain), which is a “climber cycling city” (Dufour, 2010). Therefore, we have considered variables of different natures, including the psychological ones, to analyze their relationship with bicycle commuting.

The paper is organized as follows. The methodology of the paper is described in the second section. Descriptions of the case study and the data collection process are presented in the third section. The empirical application is shown in the forth section, which is divided into two subsections. Firstly, results of the analyses over diverse traditional variables (socio-economic and household characteristics, modes availability, and commuting trip characteristics) are reported. Secondly, we determine cycling psychological latent variables and analyze their differences between different types of commuters. The last section contains some policy recommendations and conclusions.

2 METHODOLOGICAL APPROACH

The variables identified in the literature as influential in the bicycle use are numerous, and with a very diverse nature (Heinen et al., 2010). For the present research we have divided our variables according to their measuring nature. On the one hand we have the objective variables, which can be directly observed. Here we have used three types of objective variables: socio-economic and household characteristics, modes availability, and commuting trip characteristics. On the other hand, we have the subjective variables, which need the interaction of the person to be measured. In this research we have used

psychological variables, which most of the time do not have an equivalent in the objective space.

We have chosen the Theory of Planned Behavior (TPB) (Ajzen, 1991), as the framework for studying the psychological variables. It is the best-known and most widely supported attitudinal psychological theory in most studies relating to behavioral decisions, and it has been used in various studies on cycling (Bamberg and Schmidt, 1994; De Brujin et al., 2005; Eriksson and Forward, 2011; Heinen et al., 2011; Heinen and Handy., 2012; Munoz et al., 2013). The TPB states that attitudes toward a behavior, norms, and perceived behavioral control combine to shape an individual's behavioral intention and final behavior. Following the TPB, attitude toward a behavior is "the degree to which performance of the behavior is positively or negatively valued"; subjective norm refers to "the perceived social pressure to engage or not to engage in a behavior"; descriptive norm is related to"perceptions of what others are doing"; and perceived behavioral control is considered as "people's perceptions of their ability to perform a given behavior". Some studies, specifically on bicycle use, have shown that habit also has a significant influence on behavior (Verplanken et al., 1997; Stinson and Bhat, 2004; De Brujin et al., 2009; Heinen et al., 2010; Munoz et al., 2013). Therefore, habit has also been included as part of this research.

The methodology on this paper investigates the existence of statistically significant differences on different types of variables, objective and subjective, referring to the commuting mode (the mode used three or more times/week to go to the work/study place). For the analyses, the commuting mode is divided into four independent groups: bicycle (B), walking (W), public transport (PT) and car (C).SPSS®v20 was used as the statistical tool for the analyses.

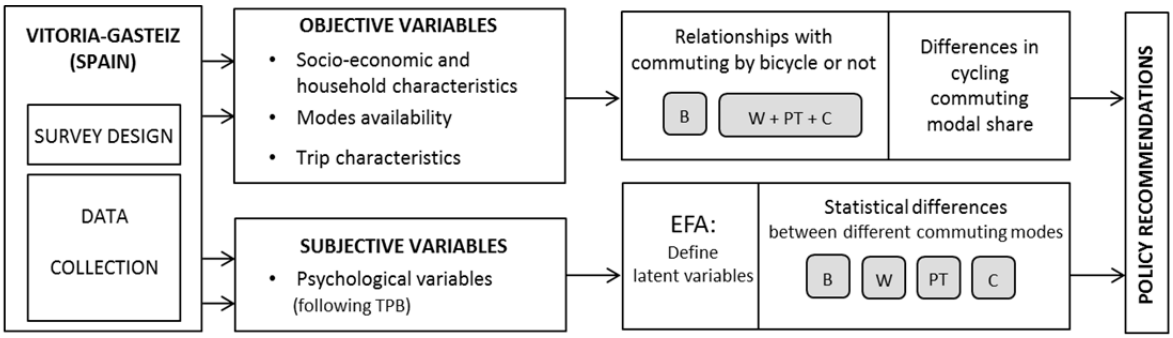

Figure 1 Methodological process

Firstly, we conduct a descriptive analysis on the sample distribution according to the objective variables, also specified for cycling commuters and non-cycling commuters. We use categorical techniques (Pearson´s chi-square test) to look at relationships between these objective variables and commuting by bicycle or not. We also analyze the commuting modal share, especially for the bicycle, comparing each specific value among

the diverse categories in each objective variable.

Secondly, we study cycling psychological variables. Since they cannot be directly measured, they are called and must be treated as latent variables and require specific analysis techniques. In practice one chooses a variety of indicators which can be measured and then attempts to extract what is common to them (Bartholomew et al., 2011). Our indicators are perceptions of cycling characteristics, which have been measured using the TPB components plus the habit. On the one hand, for the TPB components, both indicators and expected latent variables are metrical, and therefore, exploratory factor analysis is the method to obtain them. This method conveys the information contained in the interrelationships of the indicators, to a good interpretation, in a much smaller set of variables (latent variables). This way, it reduces dimensionality of indicators and improves the comprehension of their structure. Indicators with high correlation are components of the same latent variable. We apply this method to indicators of attitudes, subjective norm, descriptive norm, and perceived behavioral control (throughout two elements: controllability and self-efficacy). On the other hand, the corresponding latent variable for habit was obtained through the self-reported frequency of past behavior (Verplanken et al., 2005). Finally, we test statistical differences on the different cycling psychological latent variables defined, referring to the commuting mode choice, and using non-parametric techniques due to latent variables´ violation of normality distribution on the groups.

3 CASE STUDY DESCRIPTION

3.1 The case study of Vitoria-Gasteiz

Vitoria-Gasteiz is a dense and medium-size city (243.298 inhabitants in 2012) in the north part of Spain. It has a flat topography but a climate of moderately cold and damp winters (8ºC average temp) and cool summers (20 ºC average temp).Vitoria-Gasteiz is the city with the highest level of bicycle use in Spain. It went up fast from 3.3% in 2006 to 6.9% in 2011 (Rondinella and Munoz, 2012). It is considered a “city in transition” towards cycling, and new infrastructures and services for cycling are continuously being implemented. These interventions have a strong support from the local authorities, and they are developed in the framework of the Mobility and Public Space Plan (City of Vitoria-Gasteiz, 2007) and the Director Plan of Cycling Mobility (City of Vitoria-Gasteiz, 2010) of the city. Among others, because of this sustainable transport policy Vitoria-Gasteiz was awarded as the European Green Capital 2012.

3.2 Data collection

The research on this paper is based on data from an ad-hoc telephone mobility survey. It is the first wave of a panel mobility survey, focused on commuting trips. It was conducted among a sample of 763 employees and students from Vitoria-Gasteiz in April 2012, and

the valid final sample has been 654 surveys. The sample distribution was designed to be representative of commuting mobility, taking care of the modal share for the group "Walking + Bicycle + Public transport" (58%), and for the group of "Car + Motorbike + Other modes" (42%). In 2011, the modal split for commuting trips in the city was: 11% cycling, 38% walking, 9% public transport, 37% car, and 5% the rest of the modes (Rondinella and Munoz, 2012). Specific sampling procedures were also conducted in order to guarantee a realistic distribution of gender, age, activity sector, and work/study place location (Figure 2). Detailed origin-destination trip data were recorded for each respondent. The survey also included objective variables such as socio-economic and household data, availability of transport modes, and commuting trip characteristics; and subjective variables: psychological variables.

The psychological part of the questionnaire was designed based on the results of a qualitative study about the attitudes towards the use of the bicycle in Vitoria-Gasteiz, which consisted of 15 in depth interviews to commuters from different transport modes (Lois et al., submitted for publication). All indicators (beliefs and importances) were measured using a 7- point Likert scale ranging from completely disagree/unimportant (+1) to completely agree/important (+7).

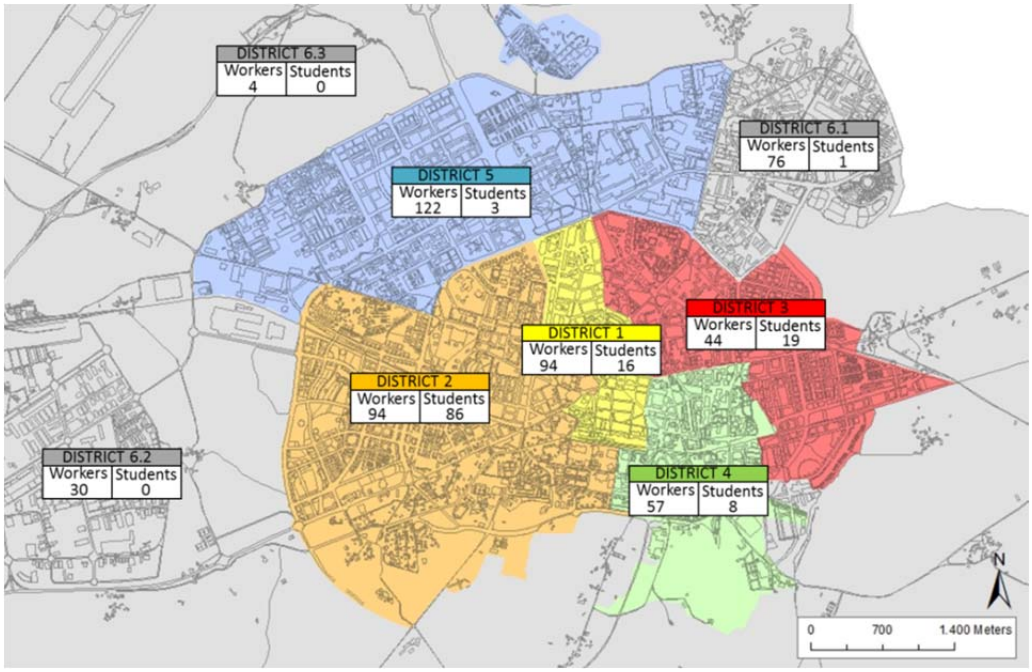

Figure 2 Sample distribution of workers and students in the city

Attitudinal indicators were calculated by multipling beliefs linking the behavior (commuting by bicycle in our case) by their corresponding importances. In our case, beliefs were asked with questions such as: "*Considering (the possibility of cycling commuting) your commuting trip, evaluate to what extent you agree or disagree with the following sentences: I (would) move quickly…*". Iindividual´s importances were stated such as: "*Evaluate to what extent it is important for you in your commuting trips: To move*

quickly…".

Subjective norm indicators were also calculated weightening beliefs by their importances. Beliefs were requested as follows: "*To what extent do you think the following groups of people agree (or would agree) with the fact that you commute (or would commute) by bicycle?*". Second, we asked about the importance, referred to the same groups of people, with the question: "*To what extent is it important for you the opinion of the following groups of people about you, commuting by bicycle?*". Questions about descriptive norm indicators were formulated: "*To what extent do you think the following groups of people commute by bicycle?*". Those groups were: *The young people, My family, My friends, My co-workers/schoolmates* and *The inmigrants.*

Controllability indicators were measured considering the question: "*To what extent you agree or disagree with the following sentences: The traffic along my trip to the work/studyplace is manageable for me to ride on the road next to cars…*". The aspects covered were: *Infrastructures, Hills, Distance, Traffic, Safe parking at home, Safe parking at work/study place*. Finally, self-efficacy indicators were asked: "*To what extent you consider yourself able to do the following tasks: To ride your bike in car traffic…".*

4 EMPIRICAL APPLICATION

The valid final sample has consisted of 654 respondents, because we have dismissed the motorbike surveys (6 respondents) due to the low percentage in the sample/population; and because we have only considered direct trips, from home to the work/study place. The final sample distribution is as follows: a) a majority that commutes by car (41%); b) a second group of pedestrians (27%); c) a group of transport users (17%); d) a minority but not inconsiderable group of cyclists (13%).

4.1 Objective variables

Table 1 shows the sample distribution according to the objective variables, and specified for cycling commuters and non-cycling commuters. We compare column proportions between the bicycle and other commuting modes. Table 2 presents the commuting modal share, for the diverse categories of the objective variables. We compare each specific modal share among the diverse categories in each objective variable.

In Table 1 we see that the majority of cyclists are men (72%), proportion which is significantly greater than the corresponding for other modes (46%). That is why bicycle share is significantly more important among men (19%) compared to women (7%). The opposite happens with the use of public transport, which is more preferred by women (26%) than by men (10%). For age groups between 25 and 54 there is no difference in column proportions between cyclists and other commuters. However, cyclists proportion

between 16 and 24 (47%) is significantly greater than the corresponding for other modes (19%). Because of that, among cyclist commuters the share for 16-24 age group (27%) is statistically higher than the rest of age groups. This group is mainly compounded by students, with more limitations to car driving. Since 25 years old, car share increases significantly, while bicycle share decreases to 8% (on average). Almost half cyclists (45%) are sons/daughters > 16 still living with their parents, proportion which is significantly greater than the corresponding for other modes (21%). This family status is the one with the bicycle share (24%) significantly higher than the others. Referring to the professional situation, Table 1 displays differences in column proportions according to cycling or not, both for employees and for students. Students triple the cycling commuting use (27%) of employed people (9%), difference which is statistically significant. Students also prefer walking (48%) significantly more than employees (22%), who choose the car in a significantly higher percentage (49%). *Gender, Age group, Family status* and *Professional situation* are associated at the level of 0.05 to the variable *Cycling commuting* (yes/no) with small size effects (Cramer´s statistics < 0.30) (Field, 2009).

Referring to mode availability variables, Table 1 indicates that most respondents have a car license (77%) and a car available to commute (84%). *Car license* shows statistical significant differences in column proportions between cyclist commuters and other modes commuters, and significant differences in the bicycle share. This produces a small association with cycling commuting. On the contrary, *Car availability* does not show any statistically difference proportions related to the bicycle, and therefore this variable is not significantly related to cycling commuting. Almost all respondents (94%) know how to ride a bicycle and the majority has a bicycle available for their commuting trips (73%). However, only 18% of the latest (13% of all respondents) choose the bicycle for commuting. Pearson´s chi-square test for the variable *Cycling commuting* and *Know to ride a bike* may be invalid because it does not accomplish the assumption of expected frequencies greater than 5 (Field, 2009). A storeroom, warehouse or parking in the residence building is the preferred place to keep the bicycle at night (73%). This variable also shows statistically significant differences in the bicycle share. *Bike availability* and *Bike parking at home,* have also a small association to the variable *Cycling commuting* (yes/no) at the level of 0.05.

Looking at commuting trip characteristics such as *Travel time* and *Travel distance,* we see that both are statistically associated at the level of 0.05 with cycling commuting, with small size effect. Most trips have duration among 10 and 30 minutes (69%). Cycling trips from 10 to 30 min (80%) are significantly higher than the corresponding in other modes (67%), and the opposite happens when trip duration is above 30 min. Vitoria-Gasteiz is a medium-size city; and therefore most cycling commuters (98%) ride a distance between 1 and 5 Km. For this distance, the bicycle share (18%) is statistically higher than for other distances.

Variables	Total		Commuting mode	
			Bicycle	Other modes
	Frequency	%	%	%
Gender [*S]	654	100%	100%	100%
Male	325	50%	**72%**	**46%**
Female	329	50%	**28%**	**54%**
Age group [*S]	654	100%	100%	100%
16-24	149	23%	**47%**	**19%**
25-34	197	27%	21%	28%
35-44	204	25%	20%	25%
45-54	128	18%	11%	19%
55-64	52	7%	**1%**	**8%**
Family status [*S]	654	100%	100%	100%
Father/Mother	264	40%	**28%**	**42%**
Son/Daughter	157	24%	**45%**	**21%**
Couple no children	132	20%	16%	21%
Without family ties	101	15%	11%	16%
Professional situation [*S]	654	100%	100%	100%
Employed	521	80%	**58%**	**83%**
Student	133	20%	**42%**	**17%**
Car license [*S]	654	100%	100%	100%
Yes	503	77%	**66%**	**79%**
No	151	23%	**34%**	**21%**
Car availability	654	100%	100%	100%
Yes	550	84%	80%	85%
No	104	16%	20%	15%
Know how to ride	654	100%	100%	100%
Yes	618	94%	100%$_1$	94%
No	36	6%	0%$_1$	6%
Bike availability [*S]	654	100%	100%	100%
Yes	479	73%	100%$_1$	69%
No	175	27%	0%$_1$	31%
Bike parking at home [*S]	479	100%	100%	100%
Inside home	128	27%	**39%**	**24%**
In storeroom/warehouse/street	351	73%	**61%**	**74%**
Travel time [*S]	654	100%	100%	100%
< 10 min	64	10%	8%	10%
10 - 30 min	448	69%	**80%**	**67%**
> 30 min	142	22%	**12%**	**23%**
Travel distance [*S]	654	100%	100%	100%
< 1 K m	83	13%	**1%**	**14%**
1 - 5 Km	472	72%	**98%**	**68%**
5 - 10 Km	67	10%	**1%**	**12%**
> 10 Km	32	5%	0%$_1$	6%

*: The Chi-square statistic is significant at the 0.05 level for cycling commuting; S:Small size association

Bold values in the same row and subtable are significantly different at p <0.05 in the two-sided test of equality for column proportions. (1): This category is not used in comparisons because its column proportion is equal to zero or one

Table 1 Distribution of the sample according to objective variables

Objective variables	Commuting mode				Total
	Bicycle	Walking	Public Transport	Car	
	13%	27%	18%	41%	
Gender					
Male	**19%**	27%	**10%**	44%	100%
Female	**7%**	28%	**26%**	39%	100%
Age group					
16-24	**27%**	**45%**	19%	**9%**	100%
25-34	**10%**	**18%**	16%	**56%**	100%
35-44	**11%**	**19%**	22%	**48%**	100%
45-54	**8%**	**27%**	17%	**48%**	100%
55-64	**2%**	**35%**	19%	**44%**	100%
Family status					
Father/Mother	**9%**	**23%**	**15%**	**50%**	100%
Son/Daughter	**24%**	**34%**	**21%**	**20%**	100%
Couple no children	**11%**	**15%**	**25%**	**49%**	100%
Without family ties	**9%**	**43%**	**9%**	**40%**	100%
Professional situation					
Employed	**9%**	**22%**	19%	**49%**	100%
Student	**27%**	**48%**	14%	**11%**	100%
Car license					
Yes	**11%**	**22%**	**15%**	**52%**	100%
No	**19%**	**44%**	**31%**	**5%**	100%
Car availability					
Yes	12%	**23%**	**15%**	49%	100%
No	16%	**50%**	**34%**	0%(1)	100%
Know how to ride					
Yes	14%	27%	**17%**	42%	100%
No	0%(1)	36%	**36%**	28%	100%
Bike availability					
Yes	18%	**25%**	**16%**	41%	100%
No	0%(1)	**33%**	**23%**	43%	100%
Bike parking at home					
Inside home	**26%**	28%	14%	32%	100%
In storeroom/warehouse/street	**15%**	24%	17%	44%	100%
Travel time					
< 10 min	**11%**	**50%**	0%(1)	**25%**	100%
10 - 30 min	**15%**	**27%**	**12%**	**45%**	100%
> 30 min	**7%**	**17%**	**46%**	**30%**	100%
Travel distance					
< 1 Km	**1%**	**94%**	0%(1)	**5%**	100%
1 - 5 Km	**18%**	**21%**	21%	**40%**	100%
5 - 10 Km	**1%**	**1%**	22%	**75%**	100%
> 10 Km	0%(1)	0%(1)	13%	**88%**	100%

Bold values in the same column and subtable are significantly different at $p < 0.05$ in the two-sided test of equality for row proportions. (1): This category is not used in comparisons because its row proportion is equal to zero or one

Table 2 Commuting modal share according to objective variables

The variables *Nationality, Family size, Children < 12*, *Level of studies*, *Car parking at home* and *Schedule type* have not been included in the results, because they are not associated to cycling commuting, and show no statistically significant differences.

4.2 Subjective variables

4.2.1 Factor analysis

The assumptions underlying factor analysis were previously checked (Hair et al., 2009): minimum sample size (654 > 5*14 indicators of attitude; 654 > 5*3 indicators of subjective norm; 654 > 5*5 indicators of descriptive norm; 654 > 5*4 indicators of controllability; 654 > 5*6 indicators of self-efficacy), and multicollinearity (Barttlet test: Sig = 0.00; MSA > 0.5). Indicators´ distributions are non-normal and therefore, we have applied the Principal Axis Factoring extraction method. The Oblimin rotation (with delta zero) was used to find the latent variables, allowing them to correlate. Factor scores representing each individual´s placement on the latent variable(s) to use in the follow-up analyses were calculated with the Barttlet method, obtaining unbiased estimates of the true factor scores (Distefano et al., 2009). Then, factor scores are standardized to mean of zero and a standard deviation of one to easy comparisons with other latent variables.

Tables 3 to 5 show the association of indicators and the definition of latent variables. They contain factor loadings from the pattern matrix (weights determining the effect of each latent variable on a particular indicator) and the proportion of indicators´ common variance explained. Cronbach's alpha coefficients were also calculated for each latent variable as a measure of internal consistency or reliability.

The characteristics *Theft safe, Weather independent, Easy to park, Easy to carry objects, Easy to carry people* and *Independent* were removed from attitudinal indicators due to low communality (<0.20). Table 3 shows the four attitudinal latent variables defined which we have named: *Life-style*, *Safety, Awareness* and *Direct disadvantages*. Labels were established taken into consideration the previous work of Heinen et al. (2011). They explain 45.70% of indicators´ common variance. The larger the factor loadings, the more a particular indicator is said to load on the corresponding latent variable. Therefore, the importance of "*Life-style*" comes from bicycle characteristics *Fun*, *Relaxing*, and *Good image* and *Daily clothing* to a lesser extent. The second latent variable "*Safety*" mixes safety issues (*Safe for pedestrian*, *Low accident risk*, *Pollution safe*) with comfortability issues (*No sweat*, *No stress*). The latent variable "*Awareness*" explains long-term benefits of commuting by bicycle such as *Environmentally beneficial*, *Healthy*, and *Cheap*. Finally more immediate indicators such as *Quick* and *Time reliable* are being explained by a latent variable. Their factor loadings are all negative, meaning that indicators are negatively correlated to the latent variable. Therefore, this label must reverse indicators´ meaning: "*Direct disadvantages*". All Cronbach's alpha coefficients are equal or greater than the

suggested minimum acceptable level of 0.7 (Hair et al., 2009), indicating that internal consistencies are acceptable, and it is therefore acceptable to use each latent variable instead of the original indicators. These latent variables correlate moderately (between 0.27 and 0.42).

Latent variables	Attitudinal indicators	Latent variables			
		Life-style	Safety	Awareness	Direct disadvantages
Life-style	Fun	0.80			
	Relaxing	0.75			
	Good image	0.52			
	Daily clothing	0.42			
Safety	No sweat		0.58		
	Safe for pedestrian		0.55		
	Stress-free		0.53		
	Low accident risk		0.51		
	Pollution safe		0.47		
Awareness	Environmentally beneficial			0.81	
	Healthy			0.75	
	Cheap			0.74	
Direct disadvantages	Quick				-0.76
	Time reliable				-0.70
% of indicators´ common variance explained: 45.70%					
Values below 0.4 are not reported					

Table 3 Factor loadings of attitudes towards characteristics of bicycle commuting

Latent variables	Subjective norm indicators	Latent variable
		Subjective norm
Subjective norm	My friends	0.97
	My coworkers/schoolmates	0.82
	My family	0.79
% of indicators´ common variance explained: 74.74%		
Values below 0.4 are not reported		

Table 4 Factor loadings of subjective norm towards characteristics of bicycle commuting

Latent variables	Self-efficacy indicators	Latent variable
		Individual capacities
Individual capacities	Hills	0.77
	Maneuver	0.76
	Fix a flat	0.67
	Ride in the traffic	0.65
	Plan a route	0.49
	Tune-ups	0.48
% of indicators´ common variance explained: 41.95%		
Values below 0.4 are not reported		

Table 5 Factor loadings of self-efficacy towards characteristics of bicycle commuting

Latent variable for psychological support for using the bicycle to commute has been created and it is shown in Table 4. "*Subjective norm*" latent variable is mainly explaining *My friends* indicator, and *My coworkers/schoolmates* and *My family* indicators to a lesser extent. Indicators´ common variance explained is the 74.74%. Internal consistency of this latent variable is acceptable ($\alpha = 0.89 > 0.70$). Table 5 summarizes the latent variable identified for self-efficacy indicators: "*Individual capacities*". Its name was assigned considering the previous work of Munoz et al. (2013). It explains the 41.95% of indicators´ common variance. It reflects the ability of respondents to overcome some cycling circumstances, such as to go up hills, maneuver by bike safely, fix a flat tire, ride in car traffic, plan a bike route, and make frequent bike tune-ups. *Park safely*, *Interpret road signs*, and *Use safety elements* were removed due to low communality (<0.20). Internal consistency of this latent variable is acceptable ($\alpha = 0.80 > 0.70$).

We tried to extract latent variable(s) for the measured descriptive norm indicators and also for the measured controllability indicators, but it was not possible due to problems of very low explained variance and unacceptable measure of internal consistency.

4.2.2 Differences between groups

In Table 6 we can see that all latent variables are significantly affected by the commuting mode (all $H(3) > 7.82$; adjusted $p < 0.071$). Mann–Whitney tests (U) between cyclists and other groups were used to follow up these findings. A Bonferroni correction was also applied and so all effects are reported at a 0.0024 adjusted level of significance. We also report the effect size (Field, 2009), measured by the Pearson´s correlation coefficient (r).

We confirm that in our sample, cycling commuters value all cycling psychological latent variables more positively (in absolute value) than non-cycling commuters. The most important latent variables for them are *Non-commuting cycling habit* (1.06), and *Individual capacities* (0.53). Lower values receive the latent variables *Direct disadvantages* (-0.49), *Safety* (0.45), and Subjective norm (0.40); while *Life-style* (0.31) and *Awareness* (0.27) show the lowest values. The negative value for *Direct disadvantages* both in cyclists and pedestrians means that they appreciate the quickness and time reliability of the cycling commuter trips as a benefit, contrary to public transport users and car users. Pedestrians give the highest values almost equally to *Direct disadvantages* (-0.23) and to the *Awareness* concern (0.21). Public transport users score more importantly in the *Life-style* latent variable (0.22), while car users do it in the cycling *Individual capacities* (-0.03).

Life-style, *Safety*, *Awareness* and *Subjective norm* do not show differences between cyclists and pedestrians or public transport users. Cyclists and pedestrians perceive no difference in *Direct disadvantages*; contrary to what happens between cyclists and public transport

users, whose effect is medium size (r = -0.27 ≈ - 0.30). The only latent variables where all comparisons differ are *Individual capacities* and *Non-commuting cycling habit*, with medium and large size effect differences respectively. This means that, cyclists significantly see themselves more prepared to overcome some circumstances related to cycling than other commuters; and at the same time, they use the bicycle for daily non-commuting trips more frequently than the others.

The study confirms that car commuters are the most strongly opposed to cycling commuters, showing the greatest differences (Munoz et al. 2013). All latent variables are significantly higher for cyclists than for car users, but for *Direct disadvantages*, where cyclist´s mean is significantly more negative, that is, less important for cyclists than for car users. *Non-commuting cycling habit* has the biggest difference (1.21) with large size effect (r = -0.47), followed by *Direct benefits* (0.75) and *Safety* (0.73) with medium effect sizes (-0.32 and -0.31 respectively). Although the rest of latent variables are significantly affected by the commuting mode choice, their size effects are small (r < 0.3).

Cycling psychological latent variables	B	W	PT	C	H_{test}	U_{test}: B-W		U_{test}: B-PT		U_{test}: B-C	
	Mean	Mean	Mean	Mean	Sig.	Sig.	E.S. (r)	Sig.	E.S. (r)	Sig.	E.S. (r)
Life-style	0.31	-0.02	0.22	-0.18	0.00*	0.00	-0.17	0.46	-0.05	0.00**	-0.20
Safety	0.45	0.14	0.10	-0.28	0.00*	0.00	-0.16	0.01	-0.16	0.00**	-0.31 m
Awareness	0.27	0.21	0.15	-0.29	0.00*	0.00	0.00	0.71	-0.02	0.00**	-0.20
Direct disadvantages	-0.49	-0.23	0.10	0.26	0.00*	0.00	-0.16	0.00**	-0.27 m	0.00**	-0.32 m
Subjective norm	0.40	0.04	0.04	-0.17	0.00*	0.00	-0.18	0.02	-0.15	0.00**	-0.25
Individual capacities	0.53	-0.11	-0.15	-0.03	0.00*	0.00**	-0.36 m	0.00**	-0.33 m	0.00**	-0.23
Non-commuting cycling habit	1.06	-0.19	-0.15	-0.14	0.00*	0.00**	-0.61 l	0.00**	-0.47 l	0.00**	-0.47 l

B: Bicycle; W: Walking; PT: Public transport; C: Car

H_{test}: Kruskal–Wallis test when 3 or more groups; U_{test}: Mann–Whitney test when 2 groups

* Significant at adjusted level: p < (0.05/ 7) = 0.0071; ** Significant at adjusted level: p < (0.05/(3*7)) = 0.0024

l: Large effect size; m: Medium effect size

Table 6 Differences of cycling psychological latent variables´ means between commuting modes

5 CONCLUSIONS AND POLICY RECOMMENDATIONS

This paper examines a varying nature of variables – objective and psychological - and their influence on cycling commuting in the context of a "climber cycling city": Vitoria-Gasteiz (Spain). Statistical differences of the variables were determined between cycling commuters and commuters by other modes.

Results show that socioeconomic and household characteristics such as *Gender, Age group, Family status* and *Professional situation*; modes availability characteristics such as

Car license, *Bike availability*, and *Bike parking at home*; and commuting trip characteristics such as *Travel time* and *Travel distance*, are associated to cycling commuting. However, all these are small associations (small size effect).We have identified and defined four attitudinal latent variables, namely "*Life-style*", "*Safety*", "*Awareness*", and "*Direct disadvantages*"; a latent variable for the psychological support for using the bicycle to commute: "*Subjective norm*"; a latent variable related to the ability of respondents to overcome some cycling circumstances "*Individual capacities*"; and a latent variable for the habit of using the bicycle for non-commuting trips "*Non-commuting cycling habit*". All these latent variables are significantly affected by the commuting mode, with medium and large size effects, contrary to what happens with objective variables.

On the one hand, "*Non-commuting cycling habit*" is the latent variable which shows the biggest differences between cycling commuters and non-cycling commuters. That is to say, increasing this latent variable with appropriated policies would produce the biggest effects when approaching non-cycling commuters to the bicycle profile. Therefore, local government should focus some of their bicycle marketing campaigns to increase that non-cycling commuters would increase their bicycle use for going out, going shopping, going on errands, etc., which is somehow related to the normalization of the bicycle as a mode of transport in the city. On the other hand, improving the latent variable "*Individual capacities*" for non-cycling commuters would represent a medium effect in the commuting mode, especially for pedestrians and public transport users. This variable could be improved with measures such as cycling courses, among others, to ride safely along the appropriate infrastructures and close to cars, and to learn how to fix a flat, to repair/maintain the bicycle, and so forth. Other efforts should be put into fostering the quickness and time reliability of the bicycle, ("*Direct Benefits*" for cycling commuters") especially for public transport or car users, throughout policies oriented to experience the cycling trip. 59% of these commuters have never tried their cycling trips, and 67% of the latest do trips shorter than 5Km. The lack of experience in this field might be influencing the results of this latent variable (Rondinella et al., 2012). Moreover, although safety is not the main barrier for cycling in Vitoria-Gasteiz, car users are also worried about the safety issue, probably due to their lack of experience too. Bicycle-specific programs, such as Bike-to-work Days, should be implemented. Evidence on the effect of this type of programs on bicycling in other places is encouraging (Pucher et al., 2010; Yang et al., 2010).

The results confirm the need to design tailored cycling policies which take into consideration the wide variety of variables influencing cycling commuting use. The objective variables analyzed allowed us to identify the cycling commuting profile in Vitoria-Gasteiz, but they showed a small effect on cycling commuting. However, analyses on psychological variables showed a higher influence, and their results allowed recommending a wide set of policy initiatives. Efforts of local government policies on bicycle promotion have produced results: Vitoria-Gasteiz has a high level of cycling share

(compared to other Spanish cities), and the safety issue is not the main barrier for cycling, as it happens in other cities less adapted to the bicycle, such as Madrid (Munoz et al., 2013). However, Vitoria-Gasteiz shares with Madrid the importance of the psychological latent variable "*Non-commuting cycling habit*" on cycling commuting, and therefore normalization of the bicycle as a mode of transport needs more progress, to reach someday the European cycling levels. Both last aspects make us call Vitoria-Gasteiz to be a city "in transition" towards cycling. This research can therefore be used as a case study to compare to other "climber cycling cities". Moreover, the extracted cycling psychological latent variables can be used as the starting point for a further analysis of the key variables that influence the use of the bicycle for daily mobility, throughout other statistical techniques, such as modelling.

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