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UNDERSTANDING CICLYSTS' PERCEPTIONS. KEYS FOR A SUCCESSFUL BICYCLE PROMOTION

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Understanding Cyclists' perceptions, keys for a successful bicycle promotion

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ABSTRACT

Increasing bicycle use has positive effects over Public Health, but the factors that command bicycle users' choice have not been identified properly. Psycho-social factors related to intention, attitudes and perceptions, have not been studied in depth and they can contribute to obtain the keys for a successful bicycle policy. Cyclists perceptions have been studied using a large university survey collected *ad-hoc* by applying exploratory and confirmatory factor analyses. After identifying four latent variables, namely convenience, pro-bike factors, physical determinants and external limitations, a structural equations model was estimated to find structure and relationships among variables and to understand users' intentions to bike. The main conclusion is that convenience and external restrictions are the most important elements to understand cyclists' behaviour. Pro-bike factors, like the health component, reinforce the element of convenience.

1. INTRODUCTION

Increasing urban cycling mobility levels is a good strategy for healthy cities (Saelens et al. 2003). It can help in two ways: avoiding urban sedentary and replacing motorized vehicle trips with all its legacy of negative externalities. Sedentary causes 3,200,000 deaths per year (Ezzati et al. 2004) and externalities (pollution, accidents and others) cause 1,500,000 deaths at year (WHO, 2009). Cycling is called to be a transport mode producing healthy effects through physical activity and reducing harmful environmental impacts (Badland and Schofield, 2008; Akar and Clifton, 2009).

Policies of cycling promotion are regarded as very important for a healthier transport and a more sustainable mobility. Policies are usually focused on transport demand management and on factors affecting bicycle use (Pucher et al. 2010). The scientific literature regarding these factors include either qualitative analyses, where bike factors (identified *a priori*) are assessed, or discrete choice models estimated to predict users' choice. Both research lines provide important insights into cyclist behaviour. However, some factors influencing cycling use are of a psycho-social type, dealing with perceptions and intentions (Eriksson and Forward, 2011; de Bruijn et al. 2005); they do not appear usually in the econometrics models and analysis normally applied. Therefore, an explicit approach to identify other non-traditional factors is needed to improve our understanding of bike users' perceptions and to increase the explanatory power of models. The aim of this paper is to capture those factors in a systematic way.

The intention is, on one hand, to identify which are the (subjective) psycho-social factors that play a role in cycling and how these factors inter-relate. On the other hand, we intend to investigate what is their influence on actual behaviour. This information is useful to gain a better understanding of users' behaviour towards riding a bicycle and to determine the appropriate actions to encourage bicycle use. For this research we have designed and applied an internet based survey in the Madrid University Campus, where a public bike system is expected to be implemented. In the next section we summarize factors that have been detected with various techniques in the cycling literature. In section 3 we describe data and how it was obtained. In section 4 we show the process to obtain the variables that best represent cyclists' perceptions. Section 5 concludes.

2. FACTORS INFLUENCING BICYCLE USE

The available literature contains a large amount information relating to factors affecting bicycle use. Some articles deal with the problem from a qualitative perspective, analysing the effects of factors by conducting evaluative surveys on cyclists; other articles perform a more quantitative analysis by linking the factors to final bicycle use. This study aims to combine both perspectives, following the steps of other authors like Li et al. (2013).

The factors influencing bicycle use can be grouped into *individual features*, cyclist *choice factors* and *latent variables*. Individual features deal with socio-demographic items, choice factors are those that can be observed and measured directly, and latent variables deal with perceptions and attitudes. Besides these variables, there are other context matters that are also important to explain bicycle use: *cyclist mobility costs*, *general transport costs* and *cyclist context conditions* (Rietveld and Daniel, 2004). Let us describe all of these factors with the help of Figure 1.

Figure 1: Factors affecting bicycle use

1. <u>*Individual Features*</u> are related to the socio-demographic characteristics of the users. Factors such as ***age*** or ***level of income*** yield different results in different studies (Baltes, 1996; Moudon et al. 2005; Dill and Voros, 2007; Pucher and Buehler, 2008). Other factors such as ***family size, car or bicycle availability*** have some direct relation with bicycle use (Ortúzar et al. 2000; Taylor and Mahmassani, 1996; Pinjari et al. 2008). A large family size or bicycle availability is associated positively with bicycle use, as opposed to car availability. Other factors such as ***gender*** seem to be related more to cycling culture than to bicycle use (Garrard et al. 2008).

2. <u>*Choice factors*</u> can be evaluated directly. These factors can be divided into those that affect us in a personal manner, those that affect us in a collective manner (related to the environment), structural factors (related to the conditions of town planning that are favourable towards bicycles) and subjective factors (related to users' explicit answer about factors and matters associated with the bicycle).

a. *Trip factors:* ***Journey duration*** is extremely important when choosing a mode of transport (Börjesson and Eliasson, 2012) although it is not as much of a decisive factor for cyclists (Tilahun et al. 2007; Eash, 1999; Hopkinson and Wardman, 1996). The roles of distance and time are closely linked. Bicycles are highly competitive with all kinds of motorised transport below certain distances (Hunt and Abraham, 2007). However, distance it is not a definitive explanatory factor (Hyodo et al. 2000; Allen-Munley et al. 2004). In addition to journey time, the ***flexibility*** offered by bicycle must also be considered as an advantage regarding waiting time for public transport or parking cost for car (Akar and Clifton, 2009). ***Trip purpose*** results a key factor according to the outcome of this research, which confirm the results obtained by other authors (Wardman et al. 2007): behaviour and decisions made by cyclists differ completely depending on trip purpose, which makes it necessary to distinguish between mandatory travel from sport, recreational and leisure pursuits (Bergström and Magnusson, 2003; Nkurunziza et al. 2010).

b. *Environmental factors* include ***weather conditions*** that can affect bicycle use, particularly when they are of a non-permanent nature, i.e. when the user cannot adapt easily to the situation. Thus, non-usual weather conditions can cause a reduction in bicycle use by a 30% (Dill and Voros, 2007; Nankervis, 1999; Shiva Nagendra and Khare, 2003). Another environmental aspect is ***topography,*** which has a clear influence on bicycle use, especially maximum gradient more than average gradient (Menghini et al. 2010). Although some towns with adverse typography exhibit a high modal rate in favour of bicycles (Cervero and Duncan, 2003; Parki, et al, 2008; Stinson and Bhat, 2003). The ***urban form*** and the urban design of spaces can directly affect bicycle use; dense and mixed uses developments favours cyclist mobility (Zahran et al. 2008; Kemperman and Timmermans, 2009).

c. *Structural factors* have always been highlighted as those *relating to a city's adaptation* to bicycle use. The existence of a ***bicycle network*** encourages bicycle use (Hunt and Abraham, 2007; Titze et al. 2008) although its importance decreases depending on the users' cycling experience (Broach et al., 2012; Taylor and Mahmassani, 1996). It is worth highlighting that a network alone is insufficient, it must also be well designed (McClintock and Cleary, 1996; Cour Lund, 2009; Carré, 1999)and with an overall connectivity (Ehrgott, Matthias, et al. 2012). Aside from the network itself, ***safe parking*** areas and lockers appear to be relevant, as well as ***additional facilities*** on site, such as showers and dressing rooms (Taylor and Mahmassani, 1996; Hunt and Abraham, 2007).

d. *Subjective factors* explicitly identified by the users. The dangerous aspect of using a bicycle could be an objective factor as we can measure the relationship between certain elements such as car traffic or speed, and accident rates (Molino and Emo, 2009; Natarajan and Demetsky, 2009;

Noland and Quddus, 2004). However, ***Perception of risk*** is a subjective matter and does not always correlate to the actual risk. Nevertheless, the fact that the user perceives risks, whether real or not, is a determining factor in relation to bicycle use (Rietveld and Daniel, 2004; Hopkinson and Wardman, 1996; Noland and Kunreuther, 1995). Other example of subjective factor than can affect the convenience of using bike is the ***exercise opportunity*** for busy people (Bergström and Magnusson, 2003).

3. Latent variables are aimed at understanding the perception of subjective factors and their internal organization. Subjective factors cannot be measured directly, but they can be grouped in latent variables that act as concepts. Thus, subjective factors are indicators of a more general idea related to the intention of biking use that we call *latent variable*. Li et al. (2013) advances on this line. Using the approach of attitudinal market segmentation, identifies six latent variables related to the perception towards bicycling: need for flexibility, sensitivity to time, need for fixed schedule, desire for comfort, desire for economy and environmental awareness.

3. **CONTEXT AND DATA**

3.1 Case study

Ciudad Universitaria in Madrid is a campus where a total of 144 centres and an associated population of 112,871 people. At present, this campus is threatened by mobility based on an increasingly intensive use of cars and an inadequate organization of its spaces. In this regard, universities are considering different actions to recover the campus as liveable area. One of these initiatives is to facilitate the use of the bicycle with the UNIBICI project. At present, bicycle is a marginal mode of transport both in the university campus as well as in Madrid itself.

Bicycles can travel across routes not covered by public transport and improve the offer of *Transport related Physical Activity* and non-polluting modes of transport. In addition, it fulfils the idea of rehabilitating communal spaces. The UNIBICI project consists of bicycle hire system for use in Ciudad Universitaria, aimed at complementing the transport network by connecting its main nodal points with the final destinations. Consequently it extends the accessibility of public transport modes and also offers a new and ideal mode of transport for internal mobility. The system proposed is a fourth generation, completely automatic, public bicycle system.

As regards modes of transport used to access Ciudad Universitaria, presently 42% of the individuals travel by metro, 26% by car, 16% by bus, 12% by foot and 4% ride their own bike. 78% of the journeys mentioned include a final stage which is made by foot, which shows that walking is the dominant mode in local displacements, involving 81% of the trips.

The environmental conditions in Ciudad Universitaria can be considered favourable for bicycles: Mediterranean climate, relatively flat and high quality landscape with some isolated slopes.

3.2 Survey development

The survey was designed to investigate the relationships between the factors and the users' subjective evaluations. The first phase of the design involved some *focus groups* including people who presently use bicycles in *Ciudad Universitaria*. These focus groups served to detect significant variables and to find out about the true requirements of the potential bicycle users on campus. Using this information, a questionnaire was prepared, which was tested by conducting a face-to-face pilot survey to 233 users at different locations within Ciudad Universitaria. Lastly, the definitive questionnaire was prepared including four fundamental sections: socio-demographic information, mobility, bicycle use combined with the *perception questionnaire* of different factors and willingness to use the future UNIBICI system in various scenarios.

The survey was conducted online from April to July 2008. To contact the target population, an e-mail was sent to the accounts provided by the different universities on campus. As a reward, and to encourage participation in the survey, approximately 1,000 reflective bands were delivered and a prize of ten foldable bicycles. The final representative sample gathered comprised 3,048 people. For a 95% confidence interval, the sampling error was 1.78% considering the most unfavourable assumption of maximum indeterminacy. The rejection rate was 22%, corresponding to the people surveyed who did not complete the questionnaire. Some 76% of people accessing the campus on a daily basis were students, the remainder were university staff. The number of people surveyed that had a job was 57%, and 70% of people surveyed had higher education qualifications. Consequently, there are an important number of part time students who combine work and study. The survey found that 74% of those surveyed stated that they would be willing to use the UNIBICI system and half of these said they would do so on a regular basis.

3.3 Psycho-social factors influencing bicycle use

The a priori selection of the most important factors was extracted from the literature summarized in section 2. These are the ones presented for assessment to the individuals in the survey. There is an evident need to assess not only factors that can be observed but also factors related to cyclists' emotions, feelings and personal perceptions. The fact that the classic factors which determine transport user behaviour – as cost and time– do not play a very important role regarding bicycles use may indicate that these other kinds of factors gain importance in the correct characterisation of cyclist behaviour (Pinjari, et al, 2008; Eash, 1999). It could be said that the part of the *black box* of behaviour that the models do not cover is very significant in the case of bicycles, and attention must be paid to it (Barnes and Krizek, 2005; Ben-Akiva, et al, 2002; Golob, 2003).

The first stage of this analysis involved the study of all of the psycho-social factors that could influence bicycle use. Factors related to bicycle use can be classified in terms of whether they are perceived as a barrier or as an incentive to bicycle use (Titze et al. 2008). We started from the classification showed in figure 1:

- Factors that promote bicycle use:
    - *Efficiency*: avoids traffic problems such as traffic jams, easy to park, enables door to door transport and is competitive with other modes of transport over certain distances.
    - *Flexibility*: no time or frequency restrictions.
    - *Economical*: no fuel expenses, the purchase and maintenance of the bicycle are economical.
    - *Ecological*: does not emit pollutants or greenhouse gases, hardly makes any noise and takes up little space.
    - *Healthy*: it is an active mode of transport that encourages people to exercise.
    - *Fun*: some users take pleasure in riding a bicycle.
- Factors that inhibit bicycle use:
    - *Distance*: distances to be travelled if they are too long
    - *Danger*: perception of risk in relation to accidents or falls
    - *Orography*: mountainous or hilly topography
    - *Fitness*: poor physical condition
    - *Climate*: weather limitations such as rain, wind, low or high temperatures
    - *Vandalism*: fear of the bicycle being stolen
    - *Facilities*: need for complementary facilities for personal hygiene, bicycle parking area at the destination point, to keep the bicycle at home, etc.
    - *Comfort*: not as comfortable as other modes of transport

The existence of cycling infrastructures has not been included as a factor because, although it is believed that it plays a subjective role that would fit in this analysis, it is captured under the perception of risk factor. Tables 1 and 2 show the evaluation of the factors from the survey. The importance given to the factors that promote bike use is, in general, greater than that given to those that inhibit its use. The factors considered most important are efficiency and the ecological aspect. The most noteworthy amongst the barriers to bicycle use are the importance given to the need for complementary facilities and the perception of danger.

Table 1: Importance of the factors that promote cycling (1 to 6 scale).

Table 2: Importance of factors that inhibit the cycling (1 to 6 scale)

These results serve to the ultimate objective of understanding the importance that bikers place on these factors, how they inter-relate and their relationship with the user's final behaviour. When working with psycho-social information, subjective evaluations and attitudes towards specific situations are far from the field of the objective variables known by modellers (LI et al. 2013). Consequently they are not in the field in which the theory of discrete choice models is a powerful tool (Golob, 2001; Pendleton and Shonkwiler, 2001; Fujii and Gärling, 2003; Vredin Johansson et al., 2006). As a result, we have preferred to use the structural equation modelling approach, to capture the underlying perceptions (Goldberguer and Duncan, 1973). This technique enabled an analysis that deals with how our factors are grouped, how they interrelate and the existence of latent variables underlying their structure (Golob, 2003).

4. METHOD AND RESULTS

First, an exploratory factor analysis was performed to observe how variables group together and to detect possible existing latent variables. Then a confirmatory factor analysis was performed to validate the results, checking the groups of indicators and the detected latent variables against the hypothesis of their contribution to the explanation of behaviour. Lastly, the structural model was formulated based on that results using Lisrel software.

4.1 Identification of latent variables

Exploratory factor analysis (Spearman, 1904; Bollen, 1989) allows us to determine which indicators contribute towards the measurement of each latent variable. It is also useful for eliminating those indicators that do not contribute to the estimation of the latent variables.

After analysing the set of responses, the first outputs showed no clear structure among indicators. This was due to the responses from those who do not use a bicycle that contributed to a dispersion of the indicators. After filtering out responses from those people who had no cycling experience (either because they did not have a bicycle, did not know how to ride one or were uninterested in cycling) a clear structure was found in the factors. This indicates that there is a significant difference in attitudes towards the bicycle between those who sometimes use a bicycle and those who never do (see Table 3) (Rondinella et al. 2012). Consequently, this shows a substantial distance between the idea of riding a bicycle - which produces a diversity of expectations - and the reality of those that do ride a bicycle, whose perceptions do respond to a verifiable common system. For example, users that frequently ride a bicycle place greater importance on factors such as efficiency, flexibility or the fun aspect and minimise the importance of factors such as perceived risk. Differences according to type of use can also be verified, as users that ride a bicycle for sport assign greater importance to negative factors such as the need for complementary facilities or fear that the bicycle could be stolen, in comparison to people who use bicycle as their usual mode of transport (Gatersleben and Appleton 2007).

Table 3: Importance assigned to different factors depending on the frequency of use or type of cycling (1 to 6 scale).

Lastly, the best adjustments were achieved by considering four latent variables. The grouping of indicators into latent variables was consistent with associations of ideas between factors, which made it possible to validate the structure and to define the meaning of the latent variables found.

The latent variables identified and their indicators were as follows:

- **CONVENIENCE:** measures the practical nature of bicycle as a mode of transport. This latent variable is related to efficiency and flexibility.
- **PRO-BIKE:** set of characteristics and factors intrinsic to the bicycle which make it an attractive mode of transport. Its indicators related to the fact that it is economical, fun, healthy and ecological.
- **EXTERNAL RESTRICTIONS:** importance of factors that restrict bicycle use and that are not under the users' control. This variable is related to the aspect of danger perception, vandalism and available facilities.
- **PHYSICAL DETERMINANTS:** measures the impedance to use of the bicycle because it is not motorised. This variable is related to the physical fitness of the user and to orography.

During the process of identification of latent variables and their association with indicators, some were eliminated because they did not add explanatory power to the structure of the factors studied; these indicators were distance, climate and comfort. These results are similar to those obtained by Li et al. (2013), where flexibility and efficiency (convenience), economical, environmental awareness or ecological (pro-bike) also appeared as indicators of the attitude towards the use of the bike. Our biggest difference with the study of Li et al. (2013) is that we have modeled factors also perceived as barriers to use.

4.2 Model of relationship between latent variables and cycling behaviour

The next step is to verify the results of the exploratory analysis by means of a Confirmatory Factor Analysis (Jöreskog, 1969). This type of analysis provides an assessment model of latent variables based on the indicators and relate them with an observed variable: user behaviour. At this stage of the modelling process, a simplified causal relationship between the four latent variables and the frequency of use of the bicycle was settled. Frequency of use of the bicycle was directly asked to respondents in the survey using six alternatives: never, once a month, several times a month, once a week, several times a week or daily.

The frequency of use is an observable variable of user's behavior. There is a difference between what we measure with our four latent variables and behavior. This difference is explained through an intermediate new latent variable that we have identified as **intention** or willingness to use (Ajzen, 1991). According to our model, the error among our measuring with the latent variables and the real use is the difference between intention and behavior. Thus, only the 54% of users with intention of using the bicycle finally used it.

Table 4: indicators determination coefficients used in the *bicycle intention use SEM*

We assessed the goodness of fit of the model using the chi-square test, the root-mean-square-error of approximation (RMSEA), the comparative fit index (CFI) and the adjusted goodness-of-fit index (AGFI). The indexes were computed using the program LISREL 8.80. The value of chi-square is 379.88 with p-value < 0.01. Besides, RMSEA=0.0743, less than 0.08 and within the 90% confidence interval; CFI=0.955, GFI=0.971 and AGFI=0.953 are larger than 0.090. On the basis of these criteria, the model fits the data properly and we can conclude that the model meets our expectations regarding statistical adequacy.

Table 4 shows the coefficients of determination and the relationships of the structural model. The results highlight that the *pro-bike* latent variable explains 75% of the variance of the economical indicator of the bicycle, 69% of its ecological aspect, 61% of its healthy aspect and 60% of the fun aspect. In addition, 85% of the variance in the efficiency indicator and 87% of the flexibility indicator are explained by the *convenience* latent variable. The *external restrictions variable* explains 35% of the variance of need for facilities, 69% of danger, and 73% of vandalism. Lastly, 60% of physical fitness and 76% of orography are explained by the *physical restriction*s variable.

The structure of the model is made of five latent variables as shown in Figure 2: *convenience, pro-bike, external restrictions, physical determinants* and *intention*. Indicators associated to the *pro-bike* latent variable include the fact that riding a bicycle is *economical*, *fun, healthy* and *ecological*. As regards the *convenience* variable, *efficiency* and *flexibility* are worth mentioning, as well as the *pro-bike* variable which explains 77% of its variance. The indicators of *external restrictions* include the aspect of *danger, vandalism, needed facilities* and *climate*. Indicators of *physical restrictions* include the *physical condition of the user* and *orography*. Lastly, *convenience, external restrictions* and *physical restrictions* explain 85% of the *intention* measured based on *frequency of use*. *External restrictions* have higher explanatory value on behaviour (β=0.75) than *convenience* (β=0.54), while *physical restrictions* appear to have a rather low impact (β=0.14).

Figure 2: Path diagram of the proposed model to explain the use of bicycle as a function of latent variables (circles) and their indicators (boxes).

Values in arrows are β coefficients: saturation rates for each relationship

The structure presented herein shows that the positive indicators associated with the bicycle can be split into two latent variables: *convenience* and *pro-bike*. The former is linked to indicators that make cycling a competitive mode of transport. The *pro-bike* includes indicators related to the pleasure of riding a bike, which have not direct influence on user behaviour, but they complement the importance given to the *convenience* variable. In other words, the model structure indicates that users take their decisions based on the *convenience* variable, which is reinforced by the *pro-bike* aspects. The β coefficients of the model allow us to calculate such indirect influence of the pro-bike variable over behaviour (intention) by using the importance placed on convenience: β=0.77 x 0.54=0.41. This means that the influence of *pro-bike* indicators are greater than those associated to *physical determinants* (β=0.14). On the other hand, all of them are less influential than *external restrictions* (β=0.75).

This logic indicates that users assign less importance to barriers that they can overcome like *physical determinants* than to the *external restrictions* that are out of their control. Consequently, the importance that the user places on physical indicators has the least influence on his/her behaviour. This can be explained by the user's capacity to adapt to these restrictions of their own accord. These results provide a hint to perform adequate policies to encourage cycling in cities.

5. CONCLUSIONS AND POLICY RECOMENDATIONS

We have used rich detailed data collected in a Spanish university campus to study the presence of latent variables that contribute to capture cyclists´ perceptions. We conclude that this approach requires the inclusion of individual experience and that there are three latent variables that summarize well these perceptions: convenience, physical determinants and external restrictions. Another latent variable, pro-bike, helps us better understand and measure the variable of convenience in a better way. Let us summarize each of these findings.

Experience

There is a clear difference between the perceptions of users that have cycling experience and those that do not have the habit of riding a bicycle (Rondinella et al. 2012). The diversity of inexperienced users' evaluations corresponds to assessments of something that is unknown to them, and it contrasts with the clear data structure shown by experienced users (Gatersleben and Appleton 2007). This leads us to reflect upon the direction that policies geared towards promoting bicycle use in the city should take. It seems logical that an adequate direction to follow should involve measures that allow people to experience cycling in real situations (Broach et al., 2012). Policies to promote public-bicycle schemes and lending bicycles services could serve to this end.

Latent variables' structure

The model outputs show that there are differences in factors related to bicycle use. These differences relate directly to user behaviour. On one hand, users differentiate factors that are perceived as barriers. Within these, they also differentiate between barriers that are under their control (*physical determinants*) from those that depend on the external actions (*external restrictions*). On the other hand, factors which encourage bicycle use are perceived as positive by users (*convenience* and *pro-bike*). The value of the indicators corresponds to real user behaviour. There are positive factors of bike-use (*pro-bike*) that are not directly related to choosing cycling as transport mode, but they have a great importance reinforce the image of convenience. Policies recommending bicycle use for better health, for preserving environment and just for fun and better social atmosphere would have clear positive effects.

External restrictions

External restrictions are perceived as much more determinant for users. Therefore, cycling oriented mobility policies can change the conditions and have an important role for promoting bicycle use. Transport planners should pay attention to eliminate this kind of barriers. Bike risk perception is referred as a very important factor in the literature (Rietveld and Daniel, 2004). Cities that want to start promoting bicycle use should design their mobility policies to get a safe cyclist network. But we should not forget that not only safety is important, but also convenience. Our results show that safety is important for non-users and convenience is important for experienced users, according to Broach et al. (2012). So combining safety and convenience would encourage non-users to consider the bicycle as an alternative and then, once they try on it, to keep on using it. In that sense, there are another ways to make bike safer in cities besides cyclist network. Friendly streets with less traffic and reduced car speed are perceived safer for inexperienced users and more convenient for cyclists.

Vandalism is also an important external restriction. It is necessary to improve security with convenient places to leave the bicycles, both in the house and in the working place. The fear of bikes' thefts is indeed a barrier for the users, higher for the inexperienced ones. It is important to design not only bike friendly urban elements, but also secure elements. It is also necessary to educate cyclists to tie correctly the bicycle when they leave it in the street, using padlocks.

Complementary facilities are not that important, but are very positively evaluated by experimented cyclists: changing rooms or taking a shower at destination, cover places to leave bikes and lockers, possibility of repairing, etc. The norms for new developments should include mandatory requirements for offices and industries in this field. Also norms for residential buildings should include facilities at ground level to leave bicycles.

Physical determinants

Physical determinants are not perceived as very important for the bicycle users. These factors are highly subjective and have the common characteristic that they are under cyclists' control so they can be changed. People could overtake them with some training or better bicycles. Only elder people or with mobility's restriction see this factor as a real barrier.

Convenience and pro-bike

The idea of convenience is related to the idea of an efficient transport mode. A convenience mode will be fast and cheap in medium-distance trips. The more these characteristics are perceived by the cyclist with the use, the more important convenience becomes to explain their decisions. Sustainable policies should be oriented to highlight these aspects of cycling mobility, showing the bicycle as a competitive transport mode for a number of trips. It is also important to transmit the image that using bicycle is for normal people, particularly in countries with low cyclist culture. This can be done by the administration with periodical awareness campaigns or implementing a public bicycle system.

Bike is a transport mode that promotes healthy habits and delivers clear benefits for the society, which have been argued in the introduction. However, health is not a very determinant factor to explain the cyclist behaviour according to Börjesson and Eliasson (2012). It is important to reduce the gap among the importance of the bicycle for the Public Health and the weight of this factor in the transport user decisions. Education policy should be carried out in three ways: promoting the advantages of *Transport-related Physically Activity*, reducing external restrictions and disseminating the convenience of bike as healthy transport mode.

The study shows that benefits for using bicycle are clearly perceived by users that look for a healthier way of life. To enlarge the number of beneficiaries it is necessary to disseminate the goodness of cycling for a better life and environment, having even better mobility patterns (efficiency and flexibility). Policies should have twofold orientations: to facilitate the use of bicycles for present non-riders and to overtake external barriers.

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Table 1

	Efficiency	*Flexibility*	*Economical*	*Ecological*	*Healthy*	*Fun*
mean	5.08	4.87	4.77	5.15	4.89	4.13
median	5.00	5.00	5.00	5.00	5.00	4.00
mode	5.00	5.00	5.00	6.00	5.00	4.00
standard deviatio	0.95	1.07	1.20	1.04	0.97	1.29

Table 2

	Distance	*Danger*	*Orography*	*Fitness*	*Climate*	*Vandalism*
mean	3.61	4.09	3.42	2.46	3.63	3.32
median	4.00	4.00	4.00	2.00	4.00	3.00
mode	6.00	6.00	4.00	1.00	4.00	4.00
standard deviatio	1.81	1.65	1.54	1.43	1.43	1.58

Table 3

Frequency of use			
	Never	**Occasional**	**Habitual**
Efficiency	5.0	5.1	5.5
Flexibility	4.8	4.9	5.3
Danger	4.2	4.1	3.7
Fun	3.9	4.3	4.9
Type of use			
	Commuter	**Leisure**	**Sport**
Vandalism	3.4	3.3	3.6
Facilities	4.3	4.5	4.7

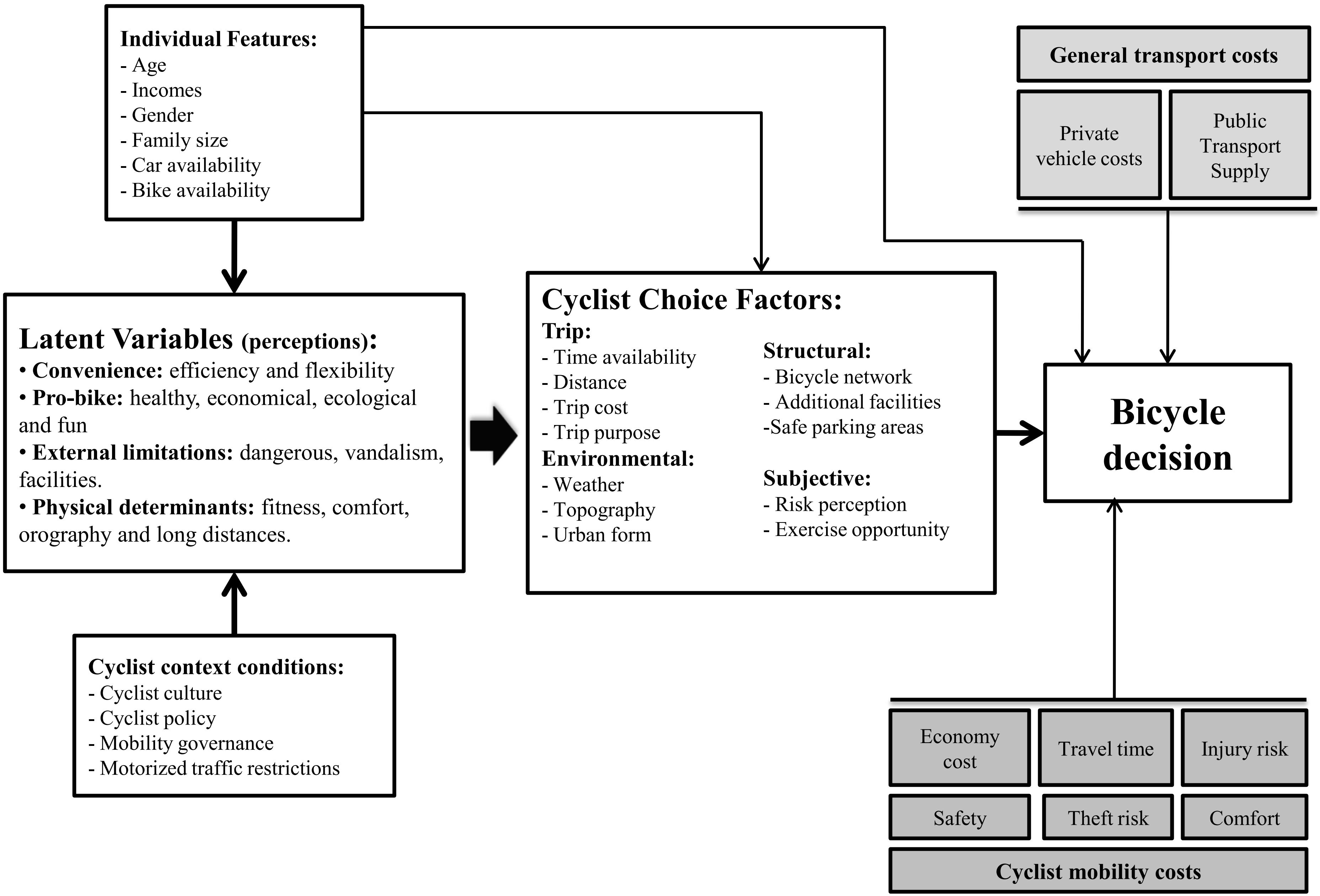
Table 4

Final results SEM

Latent variables

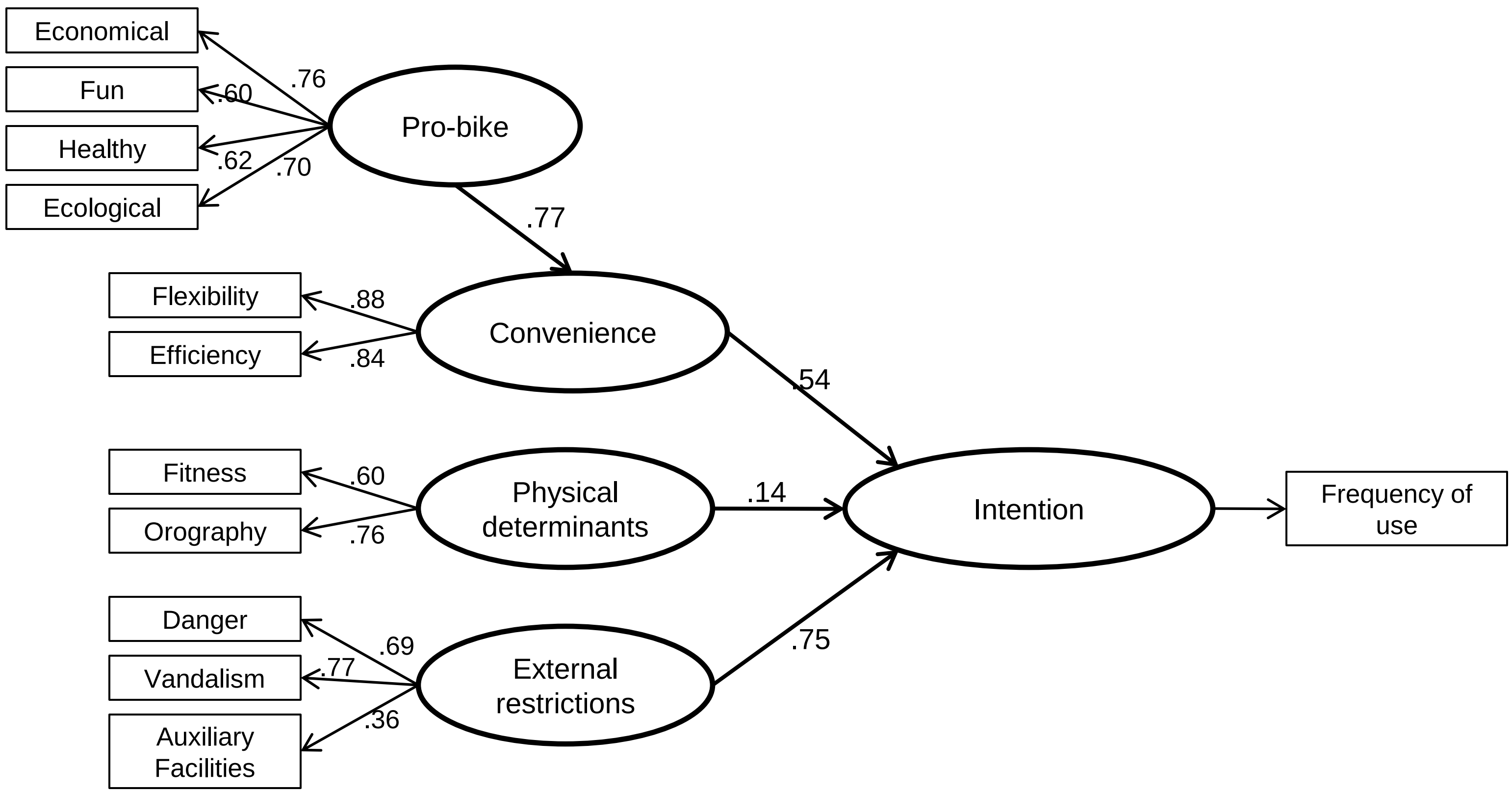
	Endogenous variables	Convenience			Pro-bike			External restrictions			Physical Determinants		
	Measurement equations												
f1	Efficiency	0.845	*	R2=0.71									
f2	Flexibility	0.878	(19.36)	R2=0.77									
f3	Economical				0.757	(18.18)	R2=0.57						
f4	Ecological				0.697	(20.19)	R2=0.49						
f5	Healthy				0.617	*	R2=0.38						
f6	Fun				0.602	(19.43)	R2=0.36						
b7	Facilities							0.357	(9.18)	R2=0.13			
b2	Danger							0.693	*	R2=0.48			
b6	Vandalism							0.773	(12.02)	R2=0.60			
b4	Forma										0.596	*	R2=0.36
b3	Orography										0.764	(4.09)	R2=0.58
	Structural equations												
	Convenience				0.772	(14.87)	R2=0.60						
	Intention	0.543	(5.94)	R2=0.88				0.752	(9.37)	R2=0.88	0.138	(1.81)	R2=0.88

Figure 1



Individual Features:
- Age
- Incomes
- Gender
- Family size
- Car availability
- Bike availability
General transport costs
Private vehicle costs
Public Transport Supply
Latent Variables (perceptions):
• Convenience: efficiency and flexibility
• Pro-bike: healthy, economical, ecological and fun
• External limitations: dangerous, vandalism, facilities.
• Physical determinants: fitness, comfort, orography and long distances.
Cyclist Choice Factors:
Trip:
- Time availability
- Distance
- Trip cost
- Trip purpose
Environmental:
- Weather
- Topography
- Urban form
Structural:
- Bicycle network
- Additional facilities
-Safe parking areas
Subjective:
- Risk perception
- Exercise opportunity
Bicycle decision
Cyclist context conditions:
- Cyclist culture
- Cyclist policy
- Mobility governance
- Motorized traffic restrictions
Economy cost
Travel time
Injury risk
Safety
Theft risk
Comfort
Cyclist mobility costs

Figure 2



Economical
Fun
Healthy
Ecological
.76
.60
.62
.70
Pro-bike
.77
Flexibility
Efficiency
.88
.84
Convenience
.54
Fitness
Orography
.60
.76
Physical determinants
.14
Intention
Frequency of use
Danger
Vandalism
Auxiliary Facilities
.69
.77
.36
External restrictions
.75