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Additional Information

Measuring Factors Influencing Valuation of Nonmotorized Improvement Measures

Tomás Ruiz (*)

Assistant Professor

Transport Department

School of Civil Engineering

Universitat Politècnica de València

Camino de Vera s/n

46022 Valencia, Spain

Tel: (+34) 963877370

Fax: (+34) 963877370

E-Mail: truizsa@tra.upv.es

&

José C. Bernabé

Gerencia Municipal de Urbanismo

C/ Iris 11 Bajo

02005, Albacete, Spain

46022 Valencia, Spain

Tel: (+34) 967 19 26 00

Fax: (+34) 967 19 26 05

E-Mail: jobergas@upvnet.upv.es

(*) Corresponding Author

ABSTRACT

This paper presents the application of a new methodology for data collection based on multiple survey methods to study how drivers and transit users value nonmotorized improvements. This multi-method survey consisted on a combination of user's willingness to change, stated tolerance and contingent valuation experiments.

Random parameter probit models were used to analyze data on willingness to cycle. Willingness to change to cycling is related to travel purpose, transportation mode, travel time and education level. Policies for promoting the use of bicycles should target these profiles so as to be more effective.

Random parameter ordered probit models were used to study how different cycling measures were valued by respondents. The protection and maintenance of cycle lanes are significantly more valued than other improvement measures. The design of future cycling facilities should consider increasing safety and travel time reduction. Senior citizen's willingness to change to cycling value to a lesser extent cycling improvement measures than people travelling to work or study. Strategies to promote cycling in each case are discussed.

KEYWORDS: Travel Data Collection Method, Nonmotorized Transportation, Cycling Improvement Measures.

1. INTRODUCTION

Car use is causing a number of harmful effects such as air pollution, congestion, traffic accidents or health quality reduction. Many government agencies and public health organizations have explicitly advocated more nonmotorized travel mode use as a way to improve health (Pucher et al., 2010). There is a growing interest in the literature in understanding people's choice of sustainable travel modes, since many surveys and experience indicate that many respondents would prefer to drive less and rely more on alternative transportation modes (Handy et al., 2005). They point out that there is a group of people who prefer to cycle and walk, and could be persuaded to do it if they had a better quality service (Gatersleben and Appleton, 2007; Litman, 2008). That is, in other words, that there is a need to facilitate cycling and walking through appropriate infrastructure and transportation policies, such as better bike paths and bike parking, traffic calming, and educational programs, and other supportive measures. However, it is not clear which measures are the most effective and should be given priority in designing and implementing a pro-bicycle policy package (Pucher et al., 2010). There is also a need to refine theories and data collection methods, improve research designs, and develop a base of evidence on walking and cycling to support more robust, realistic and targeted policy prescription (Blanco et al., 2009).

1.1 Measuring Factors Influencing Use of Nonmotorized Transportation Modes

Researchers have used different approaches to understand the factors which influence the use of nonmotorized modes. Observation data have been widely used to

characterize how existing walking or cycling facilities influence their use (Cambridge Systematics I., 1996; Landis et al, 1997; Sisiopiku and Akin, 2003).

The impacts of land use, neighborhood design, and other area-level environmental characteristics on the propensity to make nonmotorized (primarily walking) trips have been carried out relating aggregate data of these characteristics to levels of bicycle or pedestrian use, or using census data (Cervero and Radisch, 1996; Cervero and Kockelman , 1997; Dill and Carr, 2003; Parkin et al. 2008) .These studies, however, makes it difficult to examine the direct relationship between infrastructure and behavior.

Sometimes, aggregate land use data have been combined with information from travel surveys to study nonmotorized travel behavior (Cervero, 1996; Shriver, 1997; Hillman, 1998; Greenwald and Boarnet, 2001; Srinivasan and Ferreira, 2002). However, in this type of work, it is difficult to quantify the strength of the relationship because it is influenced by the scale of the analysis and the units of measurement used as well as a strong correlation between multiple factors.

Travel surveys and activity-travel surveys, at household or individual level, collect disaggregate data on current travel behavior that permit us to estimate modal choice models, including cycling and walking. For example, Stinson and Bhat (2004) evaluated the factors that affect the frequency of bicycle use for a person's commuting using data from a travel web-based survey. Kim and Ulfarsson (2008) analyzed transportation mode choice for short home-based trips using a 1999 activity survey from the Puget Sound region of Washington State, U.S.A.

An alternative approach for predicting mode used is asking respondents to consider hypothetical situations in which they are offered two or more travelling alternatives including the use of bicycle/walking. Stated preference (SP) surveys have been used extensively to collect this type of data. An early application of SP to the analysis of travel behavior (Kocur et al., 1982) demonstrated the usefulness of this approach for the analysis of cycling. Other related studies are Bovy and Bradley (1985), Hopkinson and Wardman (1996), Wardman et al. (1997), Forward (1999); Ortúzar et al. (2000), Davies et al. (2002), Rastogui and Krishna-Rao (2003), Abraham et al. (2004), Ryley (2006), Hunt and Abraham (2007), Wardman et al. (2007) and Tilahun et al. (2007).

Attitudinal surveys combined or not with other type of travel surveys have also been used to assess relative preferences for different types of facilities or using nonmotorized transportation modes. Examples of these studies can be found in Stangeby (1997), Davies et al. (1997), Mackett (2003), Krizek and Roland (2005), Loukopoulos and Gärling (2005), Walton and Sunseri (2007), Gatersleben and Appleton (2007), Kelly et al. (2007), Akar and Clifton (2009), Twaddle et al. (2010) and Chatterjee et al. (2013).

Table 1, which is inspired from Heinen et al. (2010), summarizes findings about influencing factors on cycling or walking obtained from the above mentioned studies and others. Cycling or pedestrian facilities, both on-trip and post-trip, are the most studied factors. Safety concerns and physical factors mainly related to slope of the network are also studied, negatively affecting walking or cycling. The positive influence of compact, mixed and pedestrian oriented land use is also highlighted in the literature. At the same time, some characteristics of the built environment such as traffic lights are negatively related. As expected, both short trip distances and travel times favor cycling and walking. Similarly,

cost increase of other transportation modes is also positive. Bad weather affects negatively the use of bicycle. Males, young people and part time workers are more willing to cycling. On the other hand, car ownership is negatively related to cycling. Some attitudes (education, aversion to driving) and habits (level of experience) are related to walking and cycling. Some characteristics of the trip (need to carry items, trips to work) affects in different way. Finally, the use of certain incentives can increase the use of bicycle.

The studies cited above are based on inference from large data sets, stated preference surveys on hypothetical trips, or general questions on the reasons for using a car. Macket (2003) took a set of real trips and researched why travelers used car for short trips. This paper presents a step forward in the design of data collection techniques to investigate factors influencing the use of nonmotorized travel modes, using an original multiple survey method. This consists of asking car and transit users if they are willing to switch to nonmotorized travel modes and under which circumstances they would cycle or walk for current journeys. A stated tolerance approach is used to this aim, which facilitated the consideration of walking and cycling improvement measures as key influences to use these travel modes.

1.2 Valuation of Nonmotorized Improvement Measures

The critical problem to value nonmotorized improvement measures is how to estimate a value without reference concerning market value. Bicycle and pedestrian facilities, like green zones, a non-polluted environment, and access to rural areas, represent non-market goods. It is argued that determining the value consumers place on nonmotorized improvement measures is a problematic issue since use of these travel modes

is also considered socially desirable and they provide basic mobility for the public at large. For example, it would seem contradictory and regressive to charge users a premium for using better sidewalks or paths (Litman, 2008).

Researchers in economics and transportation have devised general methods for estimating economic values attached to non-market goods and services. These include strategies to measure both revealed and stated preferences for a services or products. The former aim to identify ways in which non-market goods influence the actual market, can be estimated using methods such as hedonic pricing, travel cost or unit day values. The latter attempt to construct markets, asking respondents to apply an economic value to various goods and services. That economic value is estimated using methods such as contingent valuation (CV) or conjoint analysis (CA) (Ortúzar et al., 2000), usually named stated preference (SP) methods in transportation economics (Trawen and Hjalte, 2000).

SP surveys involve choice, ranking or rating alternatives offered to the respondent (Hensher, 1994). As described earlier, several applications of SP methods to the analysis of nonmotorized travel modes can be found in the literature. When a choice among alternatives is elicited, then the technique is called stated choice experiment (SC). In SC it is assumed that a good can be described in terms of its characteristics so that the implicit value for each of them can be obtained, as well as the marginal values of different combinations (Mackerron et al., 2009). An advantage of the choice experiment format is that it allows tradeoffs between different goods and different configurations of the same good. There is a temptation to take this property of choice experiments and go a step forward and eliminate cost as an attribute. But, in order to be able to consistently aggregate welfare actions over heterogeneous consumers one needs at least one attribute that has a

common metric. In this respect, money is the obvious attribute and there is no other substitute.

On the other hand, CV methods involve the elicitation of monetary measures of welfare: maximum willingness-to-pay (WTP) to obtain a desired good or minimum compensation (WTA) to voluntarily give up an already possessed good. CV methods can elicit economic valuation of goods in different formats. Dichotomous choice format (“yes/no” answers to pay/accept a price offered) simplifies the cognitive task faced by respondents and minimizes the number of non-responses (Mitchell and Carson, 1989; Bateman et al., 2002; Mackerron et al., 2009). Bidding game elicitation (“yes/no” answers to pay/accept a price offered depending on the answer; the price is reduced or increased until the answer is the opposite) simplifies the task to respondent, reduces the risk of strategic bias (Guria et al., 2005; Heinzen and Bridges, 2008) and encourages the respondent to consider their preferences carefully (Pearce and Özdemiroglu et al., 2002). Only a few examples of CV applications to study nonmotorized travel modes are found in the literature (Fix and Loomis, 1998; Lindsey and Knaap, 1999; Betz et al., 2003).

The major advantage of SC methods, in addition to their improved statistical efficiency, is that they permit the researcher to estimate how changes in the individual attributes across the choice alternatives alter the respondents’ choices and, hence, to value changes in individual attributes. However, SC approaches have their own limitations, mostly due to the increased cognitive burden to the respondent: alternatives may be complex and unfamiliar to the respondent, who must nevertheless make a large number of decisions. This may give rise to further problems such as: satisfying rather than utility-

maximizing behavior; increasing random errors in relation to complexity and depth of the task; and learning and fatigue effects leading to inconsistent choices (Hanley et al., 2001).

Besides, when stating a choice from a set of alternatives, it is implicitly assumed that all the attributes defining the choice have some value for the respondent (the respondent is willing to pay for them). However, this assumption might not always be right: individuals may change their mode of transportation considering only one or two attributes of each option. Regarding modal change, this means that it would make no sense for respondents to value other attributes than those needed to make them change.

The methodology described in this paper tries to overcome the problems described above. We argue that it is essential to understand which necessary conditions are needed to switch from motorized to nonmotorized travel modes. The experiment context in which modal change occurs needs to be completely understood by respondents. Then, it is more likely to yield better fitting statistical models and clearer insights regarding relevant predictive factors (Blanco et al. 2009). Additionally, we proposed a novel payment vehicle definition to value nonmotorized improvement measures not related to payment. This is more consistent with the fact that people are used to utilize cycle lanes and sidewalks free of charge.

We present the application of an original data collection methodology to explore factors influencing the valuation of measures to improve nonmotorized travel modes used in Valencia, a Spanish city located on the Mediterranean coast with approximately 800.000 inhabitants. The results obtained in willingness to change and stated tolerance surveys were used to define a contingent valuation (CV) experiment. This experiment consisted in

presenting a hypothetical scenario to respondents where the improvement measures previously selected by respondents had been implemented. In this scenario respondents had already stated that they would carry out their current journey cycling or walking. A novel vehicle payment to value improvement measures was used: respondents were asked the minimum compensation or willingness to accept (WTA) in terms of cost savings in their usual motorized travel modes to voluntarily give up cycling or walking in the hypothetical scenario.

The overall objective of this paper is to identify which policy measures to promote bicycle use should be targeted in terms of individual characteristics, the type of trip which are most likely to be switched to cycling and the measures that are required to increase cycling. The methodology underlying the surveys is explained, thus the information collected related to cycling is described and analyzed. This is followed by a description of the models used and a discussion of the factors influencing both the willingness to switch to cycling and the valuation of cycling improvement measures. The paper ends with some conclusions, policy implications and survey methodology challenges for future work.

2. SURVEY METHODOLOGY

2.1 Focus Groups

Prior to the setting up of the main multi method survey, four focus groups were created with the aid of an expert psychologist to identify the most important nonmotorized travel mode improvement measures. The four focus groups were defined as:

- Group 1: eight participants, four male and four female, aged from 21 to 51, habitual car users.
- Group 2: seven participants, three male and four female, aged from 22 to 49, habitual transit users.
- Group 3: seven participants, three male and four female, aged from 20 to 45, car and transit users.
- Group 4: six participants, two male and four female, aged from 25 to 55, car and transit users.

Most factors of interest coincided with what has been found elsewhere: facility improvement of cycle lanes/pedestrian paths and at destination, and safety increase. It was also found that the existence of clear norms on priority is an important factor. It was agreed that 4.0 kilometers is the maximum distance suitable for cycling and walking in Valencia City. The adoption of this as a priori value was supported by other results found in the literature. In WALCYNG study (1997) it was found that car trips shorter than 5 km could be replaced by walking or cycling. Gärling et al. (2000) found that the driving threshold distance was 3.4 km, whereas Loukopoulos and Gärling (2005) obtained a higher value: 4.1

km. Rastogui (2010) used 1,250 m to divide the study area to analyze walking and bicycling to access suburban rail. The boundary to include respondents in the walking stated surveys was 4500m. Those distances were previously found as an acceptable walking and bicycling distance under the transit access environment (Rastogui and Krishna Rao, 2003; Rastogui and Krishna Rao, 2002).

2.2 Population of Study and Recruitment

Car and transit users were recruited from parking spaces and bus/tram stops located throughout Valencia City when they were going to start their journey back home in the evening. Interviewers were instructed to use a non-random sampling strategy consisting on recruiting a similar number of respondents according to gender, activity and age. We decided to use this method of respondent recruitment bearing in mind that the objective of the study is to identify factors influencing both willingness to change to cycling and walking, and valuation of cycling and walking improvement measures. To this end, it is better to have a sample as diverse as possible in terms of individuals' demographics and socioeconomics, and their current travelling characteristics.

Only those whose current journey door-to-door travel time was less than 30 minutes and destination was in Valencia City were accepted to be interviewed. This value was selected because it was agreed as upper limit for cycling and walking in the focus groups, as described earlier. Surveys were carried out with the help of handheld computers and paper/showcard material. The field work was completed in Spring of 2009.

2.3 Survey Method

After recruiting a respondent who fulfilled all the requirements, the following characteristics of the current journey were collected: main activity carried out for which this journey was needed and usual travel mode for journeys as the current one. It is important to note that despite of the fact that the respondents were travelling by car or transit when they were interviewed, if respondents' usual travel mode for that journey was neither car nor transit, it was considered not valid. This was because only habitual users of those motorized modes were able to answer the following questions.

Then, respondents were asked if they would consider changing their usual travel mode (car or transit) for the current journey to walking, if improvements measures of this nonmotorized travel mode had been implemented. If respondents answered negatively to this question, they were prompted to explain the reasons for their response, and then asked the same question related to cycling. Similarly, if respondents answered negatively to this last question, they were prompted again to explain the reasons. Only if respondents were willing to cycle, were they asked about bicycle availability, cycling frequency and knowledge of bike rental systems. If respondents were neither willing to change to walking nor cycling, then the survey was concluded over. On the contrary, the survey continued asking respondents several questions to estimate monthly travel costs using the usual travel mode for their current journeys.

Stated tolerance surveys consist of asking respondents “to identify the nature and level of constraints comprising the limits of acceptability of behavioral outcomes” (Lee-Gosselin, 1995). The potential of the stated tolerance approach to explore constraints to

travel change behavior have not been considered in travel surveys so far. This type of survey was used in the next step of our multi-method survey in the following way.

Respondents who were willing to change to walking or cycling, were asked to select an improvement measure from a list, in such a way that if it was implemented, they would walk/cycle. Respondents were only asked on walking or cycling, depending on their willingness to change as previously evaluated. A showcard was presented to respondents including images describing several walking/cycling improvement measures. Interviewers gave a basic explanation on main characteristics of each alternative improvement measure. Then interviewers suggested respondents to select only one if that was enough for them to abandon usual motorized mode. But respondents were allowed to select more than one measure if they considered it necessary to change. Once respondents chose an improvement measure, they were asked to confirm that they would walk/cycle if the measures selected were implemented

[Figure 1]

In an attempt to collect data to explore factors influencing how travelers value walking and cycling improvements measures, the multimethod survey concluded defining an original contingent valuation experiment in which the payment vehicle fulfilled two conditions: first, it was not related to pay for any walking/cycling improvement measure that people are used to utilize free of charge; and second, it was as familiar as possible to respondents. Respondents were presented the following scenario: "Imagine that the measure(s) you have selected is/are implemented, and you are doing your current journey cycling/walking. A new policy permits that car/transit costs are reduced. Would you keep cycling/walking if car/transit costs are reduced by 10 percent, and your current costs would

be ... euros?" The question was customized considering the nonmotorized travel mode to which respondent was willing to change, the usual travel mode used for the current journey and the estimated monthly travel costs. The question was framed as a series of pairwise choices rather than the frequently-used open-ended form "What is the minimum amount you would accept ..." because, arguably, making a series of dichotomous choices simplifies the task and may be less likely to stimulate "strategic bias" (Guria et al., 2005; Heinzen and Bridges, 2008).

As the survey used a handheld computer display supplemented by showcard material, it was possible to present a cost reduction based on each respondent's current monthly travel costs. An initial 10 percent reduction of respondent's current monthly travel costs was offered at the starting of this bidding game. If respondent stated that he/she would keep cycling/walking in the hypothetical scenario, then an additional 10 percent reduction was offered. This process continued until respondent declared to prefer his/her current mode of transportation instead of cycling/walking. The percentage of travel cost savings reached at this point is taken as an approximation to the relative value respondents place on the improvement measures under which they decided to change. If costs reduction is 90 percent and respondents decided to keep cycling/walking, then it is assumed that those respondents are not able to value walking or cycling improvement measures. The reason was likely related to the fact that their valuation is greater than their estimated monthly travel costs.

3. MAIN SURVEY RESULTS

Only willingness-to-cycling and valuation of improvement cycling measures are considered in the present descriptive analysis and in the modeling exercise included in the next sections. A total of 1428 individuals who fulfilled conditions were surveyed on their willingness to cycle for their current journey. The number of respondents who declared not to be willing to switch to cycling was 780, which represent 54.6 per cent. One third of these respondents argued that distanced travel was too long or journey duration was too high (Table 2). As walking speed on urban pedestrian itineraries is reduced because of signalized junctions, the cycling distance threshold will not be much less than four kilometers.

Those for whom cycling is uncomfortable represent 26 per cent.

[Table 2]

Those willing to change to cycling have an average travel time of 17.02 minutes, which is obviously lower than those who are not willing to change (18.58 minutes). Travel time limitation varies depending on demographics and socioeconomics of each individual, and on travel characteristics. Those respondents willing to change who were travelling for purposes different than working/studying or shopping, have an average travel time of 14.7 minutes. Car users, those aged between 50 and 64 and with the largest household sizes, have an average travel times lower than 16 minutes. On the other hand, students not willing to change to cycle have the highest average travel time: 21.2 minutes. Those who do not pay their travel costs and those who have car available 4-5 days per week, have an average

travel times higher than 20 minutes. Among those willing to change to cycling, average travel time reduces as household size increases. Individuals in large households only can be persuaded to cycle for short trips. Possibly long trips would imply travelling with several members of the household, and the cycling alternative is not attractive.

Average travel time increases as so does the individual's education level. We have also found that high education level is related to be willing to cycle. Therefore, it is coherent that those type of respondents would be willing to cycle even for long trips.

The number of respondents who answered positively was 648, which represent 45.4 per cent, with no difference between males and females (Table 3). The younger the respondent, the more willing was to cycle. Car users were slightly less willing to cycle than transit users.

[Table 3]

Results of the stated tolerance survey are presented in Table 4. It is important to note that only one, or two at the most, improvement measures are enough for respondents to decide changing from car or transit to cycling. "Cycle lanes connected throughout the city and fully segregated" is the most selected cyclist improvement measure.

[Table 4]

The number of respondents able to value cycling improvement measures was 262, which represent 40.4 percent of those who were willing to cycle (Table 5). Females were

slightly more able to value measures. Respondents under 30 were more able to value measures. This means that car users value improvement measures much more than their monthly travel costs.

[Table 5]

Answers obtained to both willingness-to-change and tolerance surveys are "stated" responses, which usually differ from real behavior. In this respect, responses collected by the final contingent valuation survey may help to approximate who is more likely to change from those stating to doing so previously. To carry out this exercise, we assume that those respondents, who stated to keep on cycling in the hypothetical scenario for any reduction on travel costs of their usual travel model, are those who are more likely to change in the future if the improvements selected are implemented. They have a "strong" willingness to change. In contrast, those respondents who decided to stop cycling in the hypothetical scenario and to return to car or transit are less likely to change. They have a "weak" willingness to change. Table 6 includes descriptive figures on the degree of willingness to change to cycling.

[Table 6]

62.5 per cent of car users and 56 per cent of transit users stating to be willing to change to cycling were not persuaded by any reduction in their travel costs to return to their current travel modes. Therefore, they have a strong willingness to change. There is some evidence that car users are less easily influenced compared to transit users by a decrease in their travel costs once they have decided to change to cycling. Willingness to change is stronger for older respondents and transit users.

4. MODEL METHODOLOGY

4.1 Willingness to Cycle

The data collection methodology used allows us to analyze first willingness to cycle. So, probit models were selected because of flexibility: with full covariance matrix, any pattern of correlation and heteroskedasticity can be accommodated using these models. Additionally, the use of random parameters permits us to consider unobserved heterogeneity in the data. In order to determine the impact of different variables on the likelihood to cycling we used a random parameter probit model with just two options: Yes, would use cycle, or No, would not consider its use. The attributes determining choice are potentially all characteristics of the individual and trip, collected during the survey. The basic probit model formulation is:

$$\text{Prob (respondent}_i \text{ is willing to cycle)} = \Pr(Y_i^* > 0) \quad (1)$$

$$Y_i^* = \beta'x_i + \varepsilon_i \quad \text{if } y_i = 1, \quad (2)$$

$$Y_i^* = 0 \quad \text{if } y_i = 0 \quad (3)$$

where \Pr is the normal distribution function, Y_i^* is a latent willingness to cycle, β are a set of parameters to be estimated, x are explanatory variables and ε is the error term which has a normal distribution $N(0,1)$. The observed counterpart to Y_i^* is $y = 1$ if and only if $Y_i^* > 0$.

To account for heterogeneity effects, we specified a random parameter model according to the following equation:

$$\beta_i = \beta + \Gamma v_i \quad (4)$$

The equation (4) decomposes each parameter into two parts: one is the average, which is fixed and common to all respondents, while the other is a matrix of standard deviations multiplied by an unobservable random term, v_i , which is independently normally distributed. We accommodate nonrandom parameters just by placing rows of zeros in the appropriate places in Γ .

4.2 Valuation of Cycling Improving Measures

The objective of this second modeling approach is to identify factors that influence how respondents valued cycling improvement measures. This valuation is related to the likelihood of accepting to save a percentage of their usual travel costs by car or transit to give up cycling in the hypothetical scenario defined in the contingent valuation experiment. This cost savings percentage is an approximation to the relative value respondents place on those improvement measures under which they decided to cycle in the hypothetical scenario.

In this case, ordered probit models are used to analyze valuation of improvement cycling measures because information provided by respondents can be ordered considering the percentage of current travel costs savings accepted to abandon the cycling hypothetical scenario. A random parameter ordered probit model is used specified as follows:

$$\text{Prob (respondent}_i \text{ accepts cost savings percentage of 10)} = \Pr(0 \leq Y_i^* < \mu_0) \quad (5)$$

$$\text{Prob (respondent}_i \text{ accepts cost savings percentage of 20)} = \Pr(\mu_0 \leq Y_i^* < \mu_1)$$

...

Prob (respondent_i accepts cost savings percentage of 80 or 90) = $\Pr(\mu_6 \leq Y_i^*)$

where Pr is the normal distribution function, Y_i^* is a latent dependent variable and $\mu_0, \mu_1 \dots \mu_6$ are the thresholds of this latent variable. When the latent variable crosses the first threshold, the prediction is that respondents will accept up to 10 percent cost savings to stop cycling. When it crosses the second, the prediction is that respondents will accept up to 20 percent cost savings to stop, and so on. The last threshold represents acceptance of up to 80 or 90 percent cost savings. If the latent variable crosses the last threshold, it is assumed that the respondent will not accept any cost savings reduction to stop cycling in the hypothetical scenario. The latent variable also depends on a set of explanatory variables according to the following linear function:

$$Y_i^* = \beta'x_i + \varepsilon_i \quad (6)$$

where β are parameters to be estimated, x_i are explanatory variables and ε_i is the error term, which has a normal distribution $N(0,1)$. To account for heterogeneity effects, a random parameter model is specified similarly to the probit model used earlier.

The estimated parameters have no direct interpretation but can be used to calculate probabilities of accepting specific travel costs savings and their corresponding marginal probabilities. These marginal effects can be derived taken partial derivatives of the probability of accepting each specific travel cost saving with respect to each explicative variable. These are:

$$\partial \text{Prob}[\text{cell}j] / \partial x_i = [f(\mu_{j-1} - \beta' x_i) - f(\mu_j - \beta' x_i)] \times \beta \quad (7)$$

where $f(\cdot)$ is the density for the standard normal.

This estimator segregates dummy variables for separate computation in the marginal effects. The marginal effect for a dummy variable is the difference of the two probabilities, with and without the variable.

5. MODEL RESULTS

5.1 Factors Influencing Willingness to Cycle

A description of the variables used in this modeling exercise is presented in Table 7. The best model estimated for studying willingness to cycle is presented in Table 8. The models were estimated using maximum likelihood to assure consistent estimation (Greene, 2012). Positive signs of the explanatory variables are associated to an increased likelihood of willingness. All individual coefficient estimates are highly significant (at the 95% confidence level or more). Estimated scale parameters are the standard deviations as parameters are normally distributed. Standard deviations are significant, indicating that unobserved heterogeneity is well captured, except for "bike rental knowledge", for which no significant unobserved heterogeneity effect associated is evaluated.

[Table 7]

[Table 8]

McFadden Pseudo R-squared is a measure of the relative improvement in log-likelihood from a particular starting point to the log-likelihood at convergence of the model. It is calculated as $1 - LL(C)/LL(0)$, where $LL(C)$ is the log likelihood of the full model, and $LL(0)$ is the log likelihood of the intercept model. McFadden's pseudo R-squared of less than 0.1 are common and do not indicate a problem. Furthermore, AIC values are low enough and, more importantly, the model has significant chi-square value: $\chi^2 = 20.8469$, 10 df, $p = 0.0222$.

Some results are in line with previous researches. Travel time is a deterrent of cycling, as Bovy and Bradley (1985) found when studying route evaluations. Rietveld and Daniel (2004), Stinson and Bhat (2005), Riley (2006), Hunt and Abraham (2007) and Akar and Clifton (2009) also found time negatively significant to most individuals in propensity to cycle stated preference experiments. This indicates that there is a time limit for which people are able to switch to cycling.

Those usually travelling by transit are more willing to cycle than those using car. Kim and Ulfarsson (2008) also found that people are more likely to drive if they can or are accustomed to, which is indirectly related to our result: habitual car users are less likely to change their travel mode. The explanation could be that car users usually travel longer distances or they have time restrictions, which makes difficult switching to nonmotorized travel modes. As shown earlier, travel time limitation varies depending on demographics and socioeconomics of each individual, and on travelling characteristics.

The model results indicate that car drivers and transit users were more willing to cycle when traveling to work/school. However, Ortúzar et al. (2000) found a different

result. As the elicitation format to obtain the willingness to change data was similar in both studies, we conclude that only cultural and socioeconomic differences explain these opposite results.

The education status also influences the propensity to cycling. Having a higher education is more associated to cycling than having obligatory education. Possibly, more educated people are better informed of the benefits of cycling and reducing the car use. Ortúzar et al. (2000) found that those with lower educational level were more willing to cycling. Rastogi (2010) also found that commuters with better socioeconomic status were found less accommodative toward walking or bicycling modes to access suburban rail. In these cases, lower motorization levels are strongly associated with lower educational levels, which may explain this opposite result.

Availability of bicycle and knowledge of bike rental systems are logically related to cycling. Hunt and Abraham (2007) also indicated that the sensitivities to travel times on different types of cycling facilities vary with levels of experience. This shows the importance of being accustomed to using bicycles. But Tilahun et al. (2007) found that preferences of choice among several cycle facilities are not dictated by experience. This later result could be related to the fact that the majority of respondents interviewed were more or less regular bicycle users. In this situation, the stated choice experiment could not be the appropriate method to identify effects of different cyclist experience.

Those who pay their travel costs are more willing to cycle. Possibly, they are valuing to a greater extent that cycling implies saving money. This may be also related to the fact that, usually, the higher the travel costs, the more aware people are of them. But,

about 24 percent of the corresponding estimated model parameter distribution is negative. Therefore, there are a minority of people who pay their travel costs and are not willing to change to cycle. Possibly, the latter are associating cycling to purchasing a bicycle.

Shopping journeys are less related to cycling than non-shopping journeys. This is logical since most shopping trips require carrying bags on the home trip. But again, according to standard deviations of estimated random parameter in the model (Table 8), approximately 21 percent of the parameter distribution is positive. Therefore, there are a small number of individuals for whom shopping is not a deterrent for cycling. Clearly, the type of shopping the latter are referring to may not have restrictions such as carrying bags.

Employed respondents, especially when travelling to their workplace, and students are more likely to cycle than those unemployed. This may be explained by the fact that the latter have less bicycle availability. They also may be less willing to do an annual payment for a rental bike system. But housewives are not more willing to change to cycling than unemployed. Vandenbulcke et al. (2011) found that working women are less likely to cycle. In this later study, they observed men cycled more than women, which may influence their result. Additionally, they used spatially aggregated data to explain observed bicycle use, which makes it difficult to compare their results with ours.

5.2 Factors Influencing Valuation of Cycling Improving Measures

Estimation results of the best random parameter ordered probit model are presented in Table 9. Cycling improvement measures presented to respondents are described in Table 7 as dummy variables with value equal to 1 if that specific improvement measure was selected by respondents. All individual coefficient estimates are highly significant (at the

95% confidence level or more). Estimated scale parameters are the standard deviations because parameters are normally distributed. All standard deviations are significant except for the retired one. Therefore, unobserved heterogeneity is mostly well captured. R-squared and AIC values are as expected and, more importantly, the model has significant chi-square value: chi-square = 20.8469, 10 df, $p = 0.0222$.

[Table 9]

Threshold values were defined as a percentage reduction of current respondents' travel costs. First threshold is a 10 per cent reduction (category 1); second threshold is 20 per cent reduction (category 2), and so on. 80 per cent and 90 per cent reductions are grouped in the last threshold (category 8). According to model results, all thresholds defined are statistically significant at 95 percent confidence level. Average current travel costs of respondents for each threshold increases as so does the percentage reduction from 30.7 euro/month (10 per cent reduction) to 68.8 euro/month (80 per cent reduction) (Figure 2). This being logical as higher reduction can only be achieved from higher travel costs.

[Figure 2]

Because the dependent variable increases with cost savings percentage level, the coefficient estimate with a positive sign implies increased likelihood of higher cost savings percentage with an increase in the value of the explanatory variable. But to find the actual changes in probability of accepting a specific travel cost saving percentage, it is necessary to calculate marginal effects.

[Table 10]

We have different factors influencing differently the valuation of cycling improvement measures. First, we have to bear in mind that valuation is studied as a percentage of current travel costs. Therefore it is a relative valuation of cycling measures.

If respondent is employed, the probability of accepting travel costs savings of 40% and 50% increases by 21.25% and 16.38% respectively. At the same time, the chances of accepting travel costs savings of 60% and 70% reduces by 31.18% and 6.63% respectively. Similar results are obtained when work/school related trips are considered. Therefore, employees and those respondents who travel to work or school value to a greater extent cycling improvement measures.

In contrast, if a respondent is retired, the probability of accepting travel costs savings percentage of 10% and 20% goes up by 8.56% and 90.96% respectively, while the chances of accepting travel costs savings percentage of 40%, 50% and 70% goes down by 10.50%, 65.81% and 22.03% respectively.

When the improvement measure "Cycles lanes clear of obstacles" is considered, the probability of accepting travel costs savings percentage of 60% and 70% goes up by 37.66% and 18.21% respectively, while the chances of accepting travel costs savings percentage of 40% and 50% goes down by 21.61% and 38.91% respectively. "Maintenance improvements in the existing cycle lanes" only obtains slightly higher probability increases to accept 60% and 70% travel costs savings than the previous measure, and similar probability reductions to accept 40% and 50% travel costs savings.

Therefore, both cycling improvement measures tend to be valued to a similar extent. Both cycling improving measures present the highest increase of probability to be valued in threshold category 6. The average current travel costs of respondents included in this category in the contingent valuation experiment is 48.04 euro/month. Therefore, the valuation of those cycling improving measures is 60 percent reduction of this amount, that is to say 28.82 euro/month.

These results are clearly related to the fact that Valencia City already has a large cycle network (80 km in 2008), and respondents are used to seeing it as car or transit users. Cycleway maintenance measures are important for cycling as well, according to Bergström and Magnusson (2003). Clearness of obstacles is an added result to the well-known importance of cycle lane segregation (Hopkinson and Wardman, 1996; Wardman et al., 1997; Tilahun et al., 2007; Wardman et al., 2007). This improvement measure is also related to some characteristics of the built environment which deter the use of bicycle such as traffic lights and signal-control junctions (Rietveld and Daniel, 2004; Menghini et al., 2010; Vandenbulcke et al., 2011). But a small proportion of respondents valued “Cycle lanes clear of obstacles” less than others improvement measures, according to the approximately 21 percent of the estimated model parameter distribution which is negative.

Both cycling improvement measures which are statistically significant in the model are much related to travel time reduction, similarly as having separate cycling facilities, which has been found to be important in several studies (Taylor and Mahmassani, 1996; Abraham et al., 2004; Stinson and Bhat, 2005; Hunt and Abraham, 2007; Garrard et al., 2008). Taking into account that travel time/distance is a key variable for considering to

cycling, it is feasible that respondents had in mind this aspect when selected cycling measures and valued hypothetical scenarios. Additionally, these measures can also be indirectly related to an increase of perceived cycling safety (Xing et al., 2010).

6. CONCLUSIONS

This paper presents the application of an original data collection methodology to identify factors affecting the valuation of nonmotorized travel mode improvement measures. This multi-method survey consisted on a combination of willingness to change, stated tolerance and contingent valuation experiments.

Random parameter probit models were used to analyze willingness to cycling. Those more willing to switch to cycling are people currently travelling to work/school, transit users, those whose destination is no more than 17 minutes of travelling, having a higher education and those who have bike availability and are familiar with bike rental systems. A small group of shopping travelers and people who do not directly pay their travel costs are willing to change to cycling as well. Most of these results are in line with others found elsewhere. When differences are identified, in many cases the reason is that other studies found in the literature used revealed or stated preference data from only current cycling users.

A significant proportion of car and transit users whose travel time is less than 30 minutes are willing to change to cycling. Therefore, there is a substantial unsatisfied nonmotorized travel demand which could be accommodated, as found elsewhere (Handy et al., 2005). At the same time, about one third of the respondents who declared not willing to

cycle considered their travel time too high or journey distance too long. Although information collected in focus groups indicated that 30 minutes transit or car travelling time was an acceptable limit to cycling, it is possible that under certain circumstances (non-rush hour journeys) it would be better to reduce that recruitment limitation to increase response rates. Subjective perception of travel time/distance and its relation to travel mode characteristics could explain these responses as well. We suggest further research in this aspect.

Factors influencing the valuation of cycling improvement measures are analyzed using random parameter ordered probit models. To promote the use of cycling, informative actions should be focused on workers and students when they travel to their locations. Working places and educational centers are good locations to promote cycling as well. These promotion activities should include information about real travel costs, which should also be customized for individual daily/weekly travel patterns. Social marketing campaigns would be more successful if focused on transit users. Our findings also support the development of more compact urban design and mixed land use. This kind of urbanization facilitates travel times reduction and the use of cycling.

Degree of valuation of cycling improving measures may be related to the stage of change in which people are willing to cycle, following Prochaska's model (Prochaska and DiClemente, 1984). Those respondents who declared the lowest valuations could be those who had considered cycling but never tried. This being the case with retired people, who can have never tried to cycling since they became retired. On the other hand, those travelling for working or studying present a higher valuation. This clearly suggests that different strategies should be put into practice in order to convince people to change to

cycling (Gatersleben and Appleton, 2007). The latter would change if they were provided with some suggestions on how to adapt themselves to overcome personal and other commitments. To persuade retired people it would be necessary to have cycle lanes clear of obstacles and better maintenance as well.

The types of cycling improvement measures which are statistically significant in the modeling exercise tell us what respondents demand from cycling facilities. The design of such facilities must consider an increase in safety and a reduction in route distance. Type and location of traffic lights, street lamps and other urban furniture should be carefully considered so as to avoid obstructing cycle lanes. Direct cycle routes are desirable to minimize cycle travelling time.

Economic benefits of cycling include traffic decongestion and public transportation decrowding, vehicle costs savings, parking savings, travel time savings, health benefits in the form of reduced mortality and absenteeism savings, accident costs, reduced air/noise/water pollution (Saelensminde, 2004; Yi et al., 2011). In the context of the results obtained in this study, benefits associated to increase of journey ambiance should be emphasized. This benefit captures the improved level of enjoyment; improved wayfindings and perceived safety associated with the use of cycle lanes and separated cycleways relative to travelling with mixed traffic.

The original multi-method survey used in this study may be improved in order to obtain a valuation from a higher number of respondents willing to cycle. For example, the estimation period for travel costs should be extended to the whole year for those respondents with low travel costs. This would increase the number of valuation responses

specific to each improvement measure. Finally, considerably less attention has been paid to the valuation of pedestrian improvement measures in the research arena. Future work includes the analysis of related-data collected in the same survey described in this paper. More policy implications to promote walking and data collection challenges are expected to be obtained.

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