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ScienceDirect

Transportation Research Procedia 25C (2017) 2556–2569

Transportation Research Procedia

www.elsevier.com/locate/procedia

World Conference on Transport Research - WCTR 2016 Shanghai. 10-15 July 2016

Exploring the benefits of a traveller clustering approach based on multimodality attitudes and behaviours

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Abstract

This paper presents a new market segmentation study of travellers based on measures of multimodality attitudes and behaviours. The study involved a sample of researchers and clerical workers of the French national transport research institute to allow for a long and detailed questionnaire on multimodality habits. Two different cluster analyses are implemented. The first one considers variables related to the specific trip that was investigated in the survey, namely the intention to make such trip with changing travel means over time and the propensity to use a different mode in the future. The second study focuses on the more general multimodality behaviour, contemplating the actual and desired frequencies of use of different means and the propensity to try new services that are not yet existing in reality. The resulting market segments are compared and they are consistently pointing at almost the same classification of travellers. The best transport policy measures to achieve a behavioural change for each market segment are discussed.

Peer-review under responsibility of WORLD CONFERENCE ON TRANSPORT RESEARCH SOCIETY.

*Keywords:*multimodality; cluster analysis; market segmentation; traveller profiles

1. Introduction

Several different market segmentation studies have been proposed in the past to define homogeneous groups of travellers. Related clustering techniques are normally based on a wealth of variables describing socio-demographic characteristics of the population, as well as their attitudes and behaviours concerning mobility. These clusters have

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2352-1465
Peer-review under responsibility of WORLD CONFERENCE ON TRANSPORT RESEARCH SOCIETY.
10.1016/j.trpro.2017.05.295

proven their utility in defining more targeted and effective policy actions aimed at promoting behavioural changes and increasing the sustainability of transport systems.

According to Kotler et al. (2002), four types of segmentation studies can be identified: *geographic*, that considers the localization of the consumer; *demographic*, according to the personal characteristics of the individual; *psychographic*, based on lifestyle variables, including attitudes, values and belief; *behavioural*, based on the actual purchasing choices. Such different segmentation approaches have been assessed in the travel research domain by Haustein and Hunecke (2013). While psychographic segmentations have proven their utility for travel forecast and planning purposes, especially if jointly considered with an appropriate behavioural theory such as the Theory of Planned Behaviour, behavioural classifications might be easier to implement since they are based on more easily observable variables. Most of the segmentation studies in the travel behaviour research domain are indeed based in one of these latter two approaches (recent examples include Diana and Pronello, 2010; Prillwitz and Barr, 2011; Cools et al., 2012; Li et al., 2013; Damant-Sirois and El-Geneidy, 2015; Haustein and Siren, 2015; de Oña and de Oña, 2015) and have provided important feedback to decision makers on how to personalise travel-related measures to maximize the expected benefits and impacts.

On the other hand, previous research has also shown the relevance of analysing how individuals combine the use of several different travel means (Diana, 2010; Vij et al., 2013). Multimodality behaviours are therefore increasingly being studied in transport research (e.g. Kuhnimhof et al., 2012; Buehler and Hamre, 2015a,b; Diana and Pirra, in press). The purpose of the present paper is to strengthen the connection between these two research streams, namely the characterization of different travellers' profiles through market segmentation techniques and the study of multimodality, by defining a classification scheme of a given group of travellers on the basis of variables describing their multimodality behaviours and by assessing the benefits of this clustering scheme, compared to those used in this field so far.

To the best of the authors' knowledge, only two previous studies have used measures of multimodality attitudes and behaviours to draw a behavioural- and attitudinal-based market segmentation study. Diana and Mokhtarian (2009a) define behavioural market segments based on different mobility levels and the levels of use of both cars and public transport, while the segmentation presented in Diana and Mokhtarian (2009b) more explicitly considers the degree of heterogeneity of the individual modal baskets and attitudinal elements related to both the subjective assessment of the quantity of trips and the relative desired amount of travel in the future. These two multimodality-based segmentation studies have however some limitations. Since their focus is in drawing a comparison across different geographical areas (namely, France and California), variables there used to profile travellers are influenced by data availability issues and therefore are only related to objective, subjective and relative desired mobility levels related to different travel means in general terms, without a more specific reference to particular trips or to attitudes as expressed in a stated choice exercise for a specific situation.

This paper seeks therefore to more thoroughly explore the benefits of using several different measures of multimodality, both at the individual level and at the trip-specific level, to define both attitudinal- and behavioural-based homogeneous groups of travellers for which specific strategies are more effective to achieve a behavioural change to minimize the environmental footprint of the transport sector. Data gathering activities and the resulting variables that will be used to measure multimodality are presented in the following section, while section 3 details the methodology used to define the clusters. Section 4 presents the results of the analysis and identifies the best strategies of intervention for each cluster, while section 5 presents some conclusions and, complementing the discussion of section 4, lists the profiles of travellers that should be more responsive to a given measure.

2. Data

A web-based self-administered survey was carried out within the personnel of the former French National Institute for Transport and Safety Research (INRETS, now IFSTTAR) to thoroughly assess multimodality attitudes and behaviours. 164 valid responses were collected. While such individuals are not representative of a general population, their average skills and moreover their sensitivity to issues related to transport research allowed us to administer a survey that is much longer than usual. Therefore, we collected a wealth of information that could be evaluated to understand what is really useful to include in a survey aimed at capturing multimodality behaviours. This study only focuses on multimodality that can be considered to define the clusters, therefore letting aside other

well-known determinants of travel mode choices that customarily enter in mode choice models. In particular, the variables considered in the present study are defined in Table 1. Additional information on the survey and the resulting dataset can be found in Diana (2005).

Three main groups of variables, from three different parts of the questionnaire, are used in the present study. Individual-level questions are targeted at eliciting information on the general mobility habits. We consider in the following the stated frequency of use of thirteen different mechanised travel means (thus obviously excluding walking) that are listed in the first thirteen rows of Table 1. With some degree of approximation, this variable can be considered metric given the question formulation that is specified in the last column of the table. Therefore, it was decided to consider a monthly frequency of use of 15 trips for those that answered "3 times or more per week", of 8 for those using the means 1 or 2 times per week, of 3 for those using it 1-3 times per month, of 1 for those using it less frequently and of 0 for those that declared having used it never or almost never. It is acknowledged that some individuals could have difficulties in recalling their frequency of use of different travel means; on the other hand, obtaining such information through direct observation seems unpractical, since reporting periods should be long enough to capture the use of less commonplace travel means (e.g. air travel) and level weekly variations (e.g. weekdays versus weekends)

Table 1. Definition of the variables considered to build the clusters

Questionnaire section	Variable label	Definition or question	Values or measurement scale
Individual-level questions	OM_ROLLER	Frequency of use of rollers, skates or scooters	3 times or more per week / 1-2 times per week / 1-3 times per month / Less frequently / Never or almost never
	OM_BIKE	Frequency of use of bikes	
	OM_MOTO	Frequency of use of mopeds or motorcycles	
	OM_DRIV	Frequency of driving a car	
	OM_PAX	Frequency of travelling by car as passenger	
	OM_BUS	Frequency of travelling by bus	
	OM_TRAM	Frequency of travelling by tramway	
	OM_METRO	Frequency of travelling by metro	
	OM_TAXI	Frequency of travelling by taxi	
	OM_SUBURB	Frequency of travelling by suburban train	
	OM_TRAIN	Frequency of travelling by long distance train	
	OM_EAU	Frequency of travelling by boat	
	OM_AVION	Frequency of travelling by plane	
Trip-level questions	MODE_1	1st mechanised transport mode	Roller, skate or scooter / bike / car as driver / car as passenger / two-wheeled < 50cc / two-wheeled > 50 cc / urban bus / tramway / metro / suburban train / long distance train / suburban bus / taxi / employer's transport service / commercial vehicle / boat / plane / other
	MODE_2	2nd mechanised transport mode	
	MODE_3	3rd mechanised transport mode	
	MODE_4	4th mechanised transport mode	
	MODE_5	5th mechanised transport mode	
	MODE_6	6th mechanised transport mode	
	PAST_MEANS	List all transport means you used in the past to make the same trip	None else / walk / roller, skate or scooter / bike / car / moto / moped / urban bus / tram / metro / suburban train / long dist. train / suburban bus / taxi / boat / plane / other
	FUTURE_MEANS	List all transport means you would consider in the future to make the same trip	
Propensity rating exercise	SWITCH_BUS_L	Switch propensity to "bus low" service	Bipolar ordinal scale displayed through a ruler and ranging from 1 ("Very weak propensity") to 11 ("Very strong propensity") through 6 (neutral point)
	SWITCH_BUS_H	Switch propensity to "bus high" service	
	SWITCH_DRTS_L	Switch propensity to "DRTS low" service	
	SWITCH_DRTS_H	Switch propensity to "DRTS high" service	
	SWITCH_TAXI	Switch propensity to taxi service	
	SWITCH_CARPOOL	Switch propensity to carpool service	

The survey also asked the individuals to list all trips they made the day before. One trip, in which at least one mechanised travel mode was used, was randomly chosen during the survey. Therefore, the number of considered trips equals the number of survey respondents. An additional set of questions then was asked for that specific trip, including the list of all mechanised travel means being used. The questionnaire allowed recording up to 6 different means, that were stored in variables MODE_1, …, MODE_6. Further, the survey asked to list all travel modes that were used in previous occasions to complete the same (or essentially the same) trip (variable PAST_MEANS) and finally to list all travel modes that the respondent might consider using if s/he had to make the same trip in the future (variable FUTURE_MEANS).

Respondents were asked in the final part of the survey to rate their propensity to perform the same investigated trip with a non-existing transport service in the future on a bipolar 11-points scale ranging from "Very weak propensity" to "Very strong propensity". The graphical interface of the web survey allowed answering by moving a cursor along a ruler, without having to indicate any number. The proposed transport services were the following six: a cheap bus service of low quality and another of high quality and more expensive, a cheap demand responsive transport service (DRTS) of low quality and another of high quality and more expensive, a taxi service and a carpool service, and the corresponding six rating variables "SWITCH_x" are listed at the bottom of Table 1. Bus services were described by four attributes: service frequency, walking distance to/from the boarding and alighting point, travel time and fare. Demand responsive service attributes were the same, except for service frequency that was substituted with the maximum waiting time. Taxi services attributes were simply travel time and costs and the only carpooling services attribute was travel time, since it was specified that the expenses would be shared among passengers. These attributes were computed on the basis of the characteristics of the surveyed trip before being displayed to the respondent through a procedure that is detailed in Diana (2005). Figure 1 reports an example of questionnaire screenshot, reporting the two rating exercises related to variables SWITCH_BUS_L and SWITCH_BUS_H. The attribute values there displayed are random numbers, since they were all computed real time.

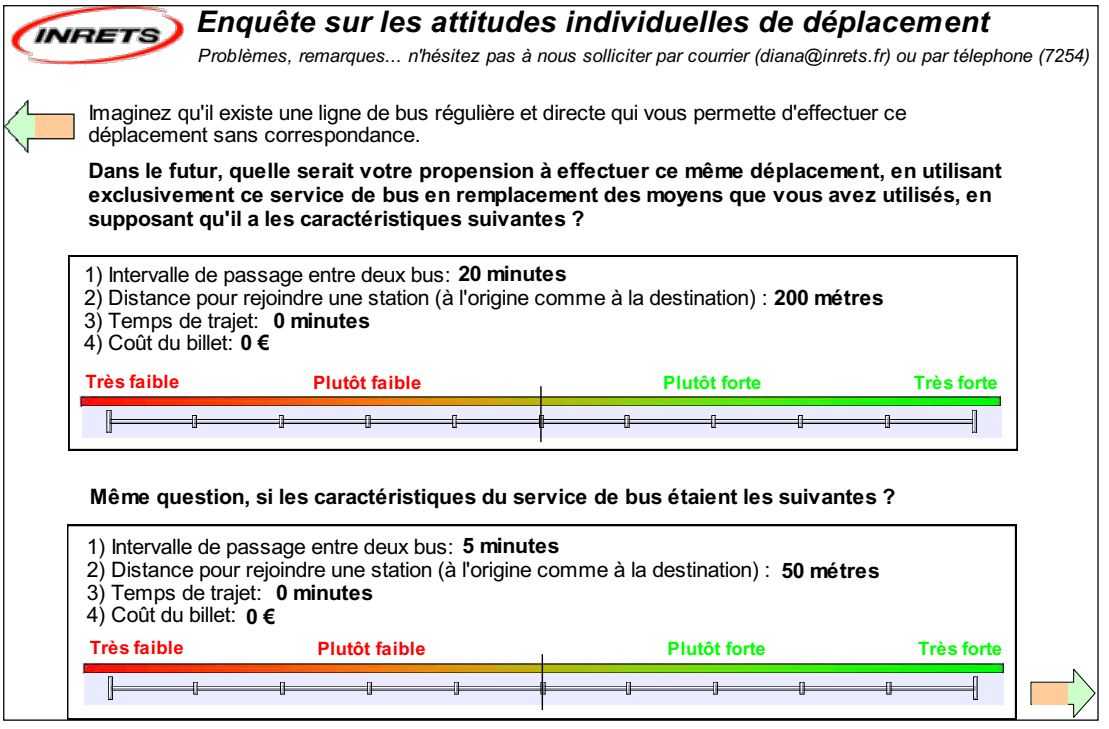

Fig. 1. Questionnaire screenshot with SP rating exercises.

From Figure 1 it is evident that this rating exercise is different from stated choice experiments commonly used in the marketing literature for at least two features. First, it was not asked to make a clear-cutting choice between two alternatives, but the strength of the attitude towards a given option was rather elicited. Second, the two alternatives were not "cognitively symmetric", in the sense that they were not both hypothetical and equally plausible. Rather, the choice task was between repeating a choice made in the past and switching to a hypothetical transport service that does not exist in reality. This framework was therefore conceived to study modal diversion rather than modal choice (Diana, 2010) and it seems particularly suited to study multimodality attitudes beyond actual behaviours, which might be highly influenced by the availability of different travel options in the real world.

The survey also asked for the standard socioeconomic characteristics of the respondents (age, sex, job, income, family structure, place of residence, car ownership etc.) that are not reported in Table 1 to save on space. Such characteristics will be later considered to more thoroughly characterise the travellers' profiles.

3. Cluster analyses: input variables and methods

A non-hierarchical k-means clustering algorithm has been used in the present research. In order to fix the number of clusters to consider, three complementary strategies have been followed since this analysis does not have goodness of fit measures. First, a trial and error procedure was implemented, repeating the analyses with different numbers of clusters until the cluster structure that is more insightful was found. Along with such empirical approach, formal hypothesis testing was carried out through a Kruskal-Wallis nonparametric test to ensure that group differences are statistically significant (as in Diana and Mokhtarian, 2009a) and we visually inspected three-dimensional scatterplots of the experimental points represented by different colours according to the cluster they belong (as done in Li et al., 2013). The Euclidean distance among observations was the considered dissimilarity measure.

Two distinct multimodality-based clustering studies are being carried out. The first one involves variables related to the specific trip that was investigated in the survey, considering the completion of such trip with changing travel means over time and the propensity to use a different mode in the future to make the same trip. The second study focuses on the more general multimodality behaviours, contemplating the actual and desired frequencies of use of different means and the propensity to try new services that are not yet existing in reality.

3.1. Trip-level multimodality clusters

In this cluster analysis, three variables summarising the variety of travel means for the trip investigated during the survey are utilized: U_GLOB, W_GLOB and SWITCH_GLOB.

U_GLOB represents the number of different travel means that have been used to complete the trip in the past. For example, if the individual has reported having used the bike and then the train to complete the trip under investigation, and then s/he indicated that both the train and the car have been used in the past to make the same trip, then U_GLOB is equal to three. U_GLOB can therefore be easily derived by combining the six variables "MODE_x" and PAST_MEANS that are presented in Table 1. It can take any value between zero (when the respondent only walked for the surveyed trip and never used a mechanized means in previous occasions for the same trip) and 15, although the maximum observed value is 5 (Rodriguez Cote, 2015).

In a similar vein, W_GLOB is derived from FUTURE_MEANS and counts how many travel modes the individual has indicated s/he might consider to make the same trip in the future. Only 15% of respondents indicated between one and three alternative means, while the majority stated that they are not considering any other mode. Therefore, FUTURE_MEANS is equal to zero for the latter group. The maximum value found in the dataset for this variable is 3.

Finally, SWITCH_GLOB captures the global propensity to switch from the already used transport modes for the macro trip, to a battery of six new transport means presented in the rating exercise part of the survey (see section 2 for additional explanations). The corresponding six SWITCH_x variables are expressed through 11-points ordinal scales, as shown in bottom right part of Table 1. Since variables are not metric, it is not appropriate to use arithmetic operations such as summations to combine them. Therefore, a method described in Diana et al. (2009) was used to properly combine such ordinal variables into a single score. Scores were computed by considering that some of the

six alternative travel services are correlated, leading to the hierarchical structure depicted in Figure 2. Score values ranged from -148 to +143, higher values indicating overall higher propensity of the respondent to use new services for the trip under investigation in the future, compared to the rest of the sample.

We believe that, taken together, these three variables can well represent both more generic attitudes related to changing travel means in the future for a given trip and a more focused choice task eliciting a more rational consideration of competing travel means, along with the actual behaviours concerning multimodality. All three variables have been standardized given the different orders of magnitude of the values that they can take.

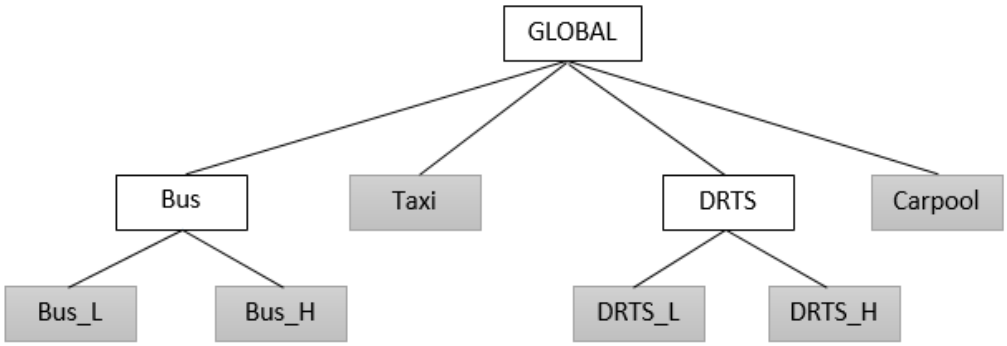

Fig. 2. Hierarchical structure to combine the ordinal variables from the SP choice experiment.

3.2. Individual-level multimodality clusters

Trip-level analysis is helpful in characterizing clusters of travellers on the basis of acted behaviours or opinions related to a specific trip, and we believe that such reference to something that really happened can give soundness to the classification exercise. On the other hand, the trip under investigation was randomly selected among those being performed by the individual the day before the interview, and therefore it might not well represent the general multimodality attitudes of the respondent. Therefore, the previous analysis is complemented with another one that seeks to explore such more general viewpoint. To achieve this we run an additional set of analyses where, along with the previously defined SWITCH_GLOB variable, we consider two new variables: OM_GLOB and OM_PI. The variable SWITCH_GLOB is kept from the previous market segmentation. Although this variable is considering exclusively the propensity to switch mode in the surveyed trip, there might be also a correlation to the general multimodal behaviour of the individuals. Also these three variables have been standardized, like in the previous analysis.

Turning now our attention to the two new variables, the global objective mobility OM_GLOB represents the total number of trips made by the individual, regardless of which transport modes used, the month before the interview. This variable is calculated by summing the "OM_x" variables pertaining to the individual transport modes that are listed in Table 1, after having transformed the answers into monthly frequencies as described in section 2.

On the other hand, the "objective mobility pure multimodality index" OM_PI was introduced as a multimodality measure in Diana and Mokhtarian (2009b) and it ranges between zero, when the individual uses only one travel means to make all trips, to one, when all the considered travel modes are used with exactly the same frequency. OM_PI is computed from the same variables that are used to compute OM_GLOB. In our sample, the range of values is between 0 and 0.85: the distribution of values is represented in Figure 3.

To have a deeper understanding of what practically represents a given OM_PI value in the sample compared to the number of modes used with their respective frequency of use, we considered the 13 bins of values represented in Figure 3 and we checked in the dataset the most common modal mix within each bin. Such modal mix is reported in Table 2, where columns exclusively report those modes that appear in the most common modal mix of at least one group. For example, in the first row of the table we see that the relative majority of the group of the "most

monomodal" respondents (those having OM_PI less than 0.07, and we see from Figure 3 that they are 4) are driving a car at least 3 times a week (corresponding to an estimated monthly frequency of 15 trips, as detailed in section 2) and are never using any other mechanised transport mode. At the other extreme, the most common modal mix of the group of 4 "most multimodal" people is reported in the last row of Table 2. Quite interestingly, the majority of this group reports the highest frequency of cycling and uses, at least occasionally, eight other different transport modes.

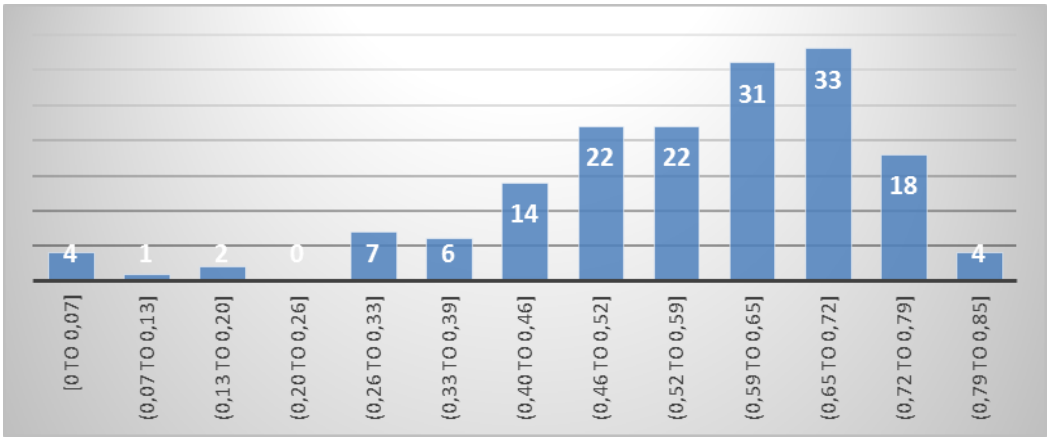

Fig. 3. Distribution of OM_PI.

Table 2. Most common modal mix for 13 bins of survey respondents; values represent estimated monthly frequencies of use.

OM_PI	OM_BIKE	OM_CARDR	OM_CARPAX	OM_BUS	OM_TRAM	OM_METRO	OM_TAXI	OM_SUBURB	OM_TRAIN
[0 to 0.07]	0	15	0	0	0	0	0	0	0
(0.07 to 0.13]	0	15	1	0	0	0	0	0	0
(0.13 to 0.20]	0	1	15	0	0	0	0	0	1
(0.26 to 0.33]	0	15	8	0	0	0	0	0	0
(0.33 to 0.39]	1	15	3	0	0	0	0	0	1
(0.39 to 0.46]	0	15	1	1	0	1	0	1	1
(0.46 to 0.52]	0	15	3	3	0	3	0	0	0
(0.52 to 0.59]	0	15	3	1	1	3	1	0	1
(0.59 to 0.65]	0	15	3	3	3	3	0	0	1
(0.65 to 0.72]	0	15	8	3	3	3	1	0	1
(0.72 to 0.79]	0	0	8	15	8	15	1	15	1
(0.79 to 0.85]	15	8	3	3	3	8	1	1	3

4. Travellers groups and corresponding transport policy measures

4.1. Trip-level multimodality clusters

By following the previously described methodology to choose the appropriate number of clusters, considering first trip-level variables we defined the solution with four clusters described in Table 3 (one column per cluster). The standardized mean values for the three above clustering variables U_GLOB, W_GLOB and SWITCH_GLOB are reported in italicized rows. Negative values are therefore an indication that the corresponding cluster mean value is lower than the overall mean value for the considered variable.

Table 3. Trip-level multimodality clusters

Variable	A) Low multimodal, open to change	B) Car monomodalists, eager to change	C) Multimodal, carpool interested	D) Low multimodal creatures of habit
U_GLOB (std)	*-0.5*	*-0.2*	*1.3*	*-0.6*
U_BIKE	5%	0%	33%	14%
U_MOTO	7%	0%	4%	6%
U_CAR	63%	100%	85%	71%
U_BUS	32%	14%	83%	14%
U_TRAM	0%	0%	28%	3%
U_METRO	25%	14%	83%	17%
U_TAXI	0%	14%	4%	0%
U_SUBURB	8%	14%	28%	9%
U_TRAIN	0%	14%	9%	0%
W_GLOB (std)	*-0.1*	*4.0*	*-0.2*	*-0.4*
W_BIKE	12%	29%	9%	0%
W_MOTO	0%	57%	0%	0%
W_CAR	5%	0%	2%	0%
W_BUS	0%	57%	0%	0%
W_TRAM	0%	14%	0%	0%
W_METRO	0%	29%	0%	0%
W_TAXI	0%	0%	0%	0%
W_SUBURB	0%	0%	0%	0%
W_TRAIN	0%	14%	0%	0%
SWITCH_GLOB (std)	*0.5*	*0.3*	*0.2*	*-1.3*
SWITCH_BUS_L	3	3	3	1
SWITCH_BUS_H	5	2	4	1
SWITCH_DRTS_L	3	2	3	1
SWITCH_DRTS_H	4	3	3	1
SWITCH_TAXI	3	3	2	1
SWITCH_CARPOOL	7	9	7	3
Number of observations	76	7	46	35
%	46	4	28	21

In order to give a fuller characterization of the clusters, Table 3 also reports the mean cluster values of the variables that were used to define the clustering variables in indented rows. More specifically, "U_" variables in the first indented block of rows indicate the average percent of individuals belonging to a given cluster that indicated having used a given travel means to perform either the investigated trip or the same trip in the past. Taxi and train are the least used alternative transport modes across the four clusters, while the car is the most used. Indented "W_" variables in the second block represent the percent of individuals that would consider using the corresponding mode to make the same trip in the future. Quite interestingly, the car is very seldom considered as a future option, sharply contrasting with its reported past use as an alternative means. Social desirability biases and "wishful thinking" might have affected such responses. Finally, indented "SWITCH_" variables display the mean propensity level to switch to one of the six new transport services to perform the same trip in the future. We recall that answers in the SP experiment were on an 11 point scale where 6 represents a neutral attitude. Therefore, mean values below this threshold indicate that respondents are rather unwilling to switch to the proposed modes, and the contrary happens for values above 6. Carpooling services seem to have a good potential compared to more traditional transport services such as taxis or buses.

Bearing in mind the meaning of numbers that can be read in Table 3, the four different market segments can be interpreted as follows:

- *A) Low multimodal, open to change*: Almost half of the sample belongs to this market segment. It is a group that has used a small number of transport means to complete the surveyed trip in relation to the average. The car in this group is not as popular as it is in other clusters. In relation to the average, individuals are slightly less interested in performing this specific trip with alternative modes. On the other hand, this group is the most interested in relation to the average to switch to the new proposed transport modes, especially to the carpooling service. Since the propensity to switch to the expensive, high quality bus service is negative but close the neutral point, it might also be of interest for some individuals in this segment.
- *B) Car monomodalists, eager to change*: Very small group of individuals (7 cases) that have used a not so small number of transport means to complete the random asked trip in relation to the average. All the individuals have used the car in the surveyed trip, and a small percentage has used alternative modes also, such as the metro and the bus to complete the journey. In relation to the average, they would like to use a lot the alternative transport means, especially motorcycles and buses. Respondents are interested in relation to the average to switch to the new proposed transport modes, in particular to the carpooling service.
- *C) Multimodal, carpool interested*: Almost thirty percent of the sample belongs to this market segment. This group has used a higher number of transport means to complete the surveyed trip in relation to the average, mainly car and public transport. No individual has used the taxi or the motorcycle. Bicycles are the only transport mode that is contemplated for repeating the same trip in the future that has not already been used, but is considered by only nearly 10% of the respondents. On average, this cluster has a high propensity to switch to the proposed carpool service to make the trip. This market segment confirms what was concluded in Diana (2010), since individuals who use a variety of transport means are more open to try diverse modes, even those that they do not know.
- *D) Low multimodal creatures of habit*: Almost twenty percent of the sample belongs to this market segment. It is a group that has used the smallest number of transport means to complete the surveyed trip in relation to the average, where nearly 70% of the individuals have used the car and nearly 20% the metro. All the variables with the prefix "W_" followed by a label indicating the mode in this cluster are equal to 0%, meaning that no individual in this cluster is interested in performing the same random trip in the future with any of the proposed services.

On the basis of the above interpretation of the clusters and of their additional socioeconomic profiling that is reported in Table 4, different measures can be envisaged to promote the use of more sustainable transport systems:

- *A) Low multimodal, open to change*: This market segment is characterized by the highest overall interest in new transport services (captured through “SWITCH_x” variables), while it seems not interested to switch to existing travel means (represented by “W_x variables”). Because it was checked that it is the wealthiest cluster and the propensity to switch to the high level bus service is close to the neutral point, these individuals might be interested in new operating schemes such as bus rapid transit. As in clusters “Car monomodalists, eager to change” and “multimodal, carpool interested”, it could also be suitable to encourage the carpooling service, especially for home based work trips.
- *B) Car monomodalists, eager to change*: This cluster shows the highest potential for mode switch. However, even if travellers in this group might consider in general terms performing the same trip with different travel means in the future, the stated choice experiment shows that the most substantial positive attitude is towards carpooling solutions. Therefore, this specific transport service should primarily be promoted. Voluntary travel behaviour change programs would be particularly helpful to reduce the wide gap between attitudes and intentions (wider than in all other groups) that is noticeable when comparing the “W_” and the “SWITCH_” groups of variables.
- *C) Multimodal, carpool interested*: In this case, individuals already use a variety of means, so they need to be reinforced in their environmentally sustainable choices. Promoting schemes such as park and ride, or easing the transport of bicycles on-board public transport vehicles could be quite effective for this segment. New services such as carpools are also likely to be appreciated.
- *D) Low multimodal creatures of habit*: For about 20% of the sample, it might be very difficult to try to change their attitudes to use alternative modes. Persuasive messages regarding the negative externalities of the

automobile, rather than a direct change in the offer of alternative services might be the only option to achieve a change of attitudes and, only in a second stage, of behaviours. However, such actions need to be carefully planned to avoid obtaining the opposite effect, namely a reinforcement of the habit, through psychological reactance mechanisms (Tertoolen et al., 1998).

Table 4. Socioeconomic characterisation of trip-level multimodality clusters

Variable	A) Low multimodal, open to change	B) Car monomodalists, eager to change	C) Multimodal, carpool interested	D) Low multimodal creatures of habit
% females	59.2%	28.6%	45.4%	54.3%
Number of people in the household	2.73	2.57	2.58	2.66
% household annual income < 25000 €	27.4%	33.3%	44.4%	36.7%
% household annual income > 60000 €	15.9%	0	13.3%	9.1%
Number of cars in the household	1.37	1.57	1.02	1.43

4.2. Individual-level multimodality clusters

Both the trial and error process and the cluster visualization procedure confirmed that the five cluster solution that is displayed in Table 5 is the most appropriate in this case. The resulting clusters have also statistically different mean values according to the Kruskal-Wallis test. Table 5 has the same format of Table 3: along with the italicized rows displaying the standardized means for the clustering variables, two additional blocks of indented rows further characterize the clusters. Variables that are named with the prefix ‘‘OM_” followed by a label indicating the transport mode report the approximated number of monthly trips performed by each mode. The variables with the prefix “SWITCH_” have the same meaning of Table 3.

The five resulting clusters can be interpreted as follows:

- *1) Multimodal public transport heavy travellers, interested in new modes:* 21% of individuals belong to this market segment. It is a group that has its mobility level and its pure multimodality index values significantly above the average, meaning that those travellers regularly use a variety of modes, and travel a lot compared to the whole sample. Driving a car is not as popular in this group as it is in the other clusters, while the highest frequency of trips made as a passenger in a private car was observed. On the other hand, buses and metro are the most popular modes inside the group, and are the most used means in relation to the other clusters. On average, all the transport means have been used at least once in this group. In relation to the average, the individuals have a high tendency to switch to the new proposed transport modes for the surveyed trip, particularly to the carpooling service. Since the propensity to switch to the high quality bus service and to the high quality demand responsive transit service is close the neutral point on average, some individuals in this segment might also be interested to use such means.
- *2) Car-dominated light travellers, carpool interested:* Nearly half of the individuals belong to this market segment. It is a group that has its mobility level value slightly below average and its pure multimodality index value equal to the average. The most popular transport mode in this cluster is driving a car; however, other transport modes such as the bus and the metro are also used with a non-negligible frequency. In relation to the average, individuals have a smaller aversion to switch to the new proposed transport modes for the random asked trip, in particular to the carpooling service.
- *3) Monomodal light travellers, interested in new modes:* Only 9% of the sample belongs to this market segment. It is a group that has its mobility level and its pure multimodality index value significantly below the average, meaning that the individuals use rarely diverse modes, and they do not travel a lot compared to the whole sample. The group is characterized for using almost always the car for its journeys; more as a driver than as a passenger. In relation to the average, individuals have a smaller aversion to switch to the new proposed transport modes for the investigated trip, in particular to the carpooling service.
- *4) Multimodal heavy travellers, not interested in new modes:* 16% of the sample belongs to this market segment. As for the market segment “multimodal public transport heavy travellers, interested in new modes”, this group

has its mobility level and its pure multimodality index values significantly above the average and all the transport means have been used at least once. On the other hand, in relation to the average, individuals have a very low propensity to switch to the new proposed transport modes for the random asked trip.

- *5) Car-dominated light travellers, not interested in new modes:* 12% of the sample belongs to this market segment. It is a group that has its mobility level and its pure multimodality index values significantly below the average, in which driving a car is the most common transport mode used for the travellers, while alternative modes are utilized with a very low frequency. In relation to the average, individuals have a very low propensity to switch to the new proposed transport modes for the random asked trip.

Table 5. Individual-level multimodality clusters

Variable	1) Multimodal public transport heavy travellers, interested in new modes	2) Car-dominated light travellers, carpool interested	3) Monomodal light travellers, interested in new modes	4) Multimodal heavy travellers, not interested in new modes	5) Car-dominated light travellers, not interested in new modes
OM_GLOB (std)	*1.3*	*-0.4*	*-1.2*	*0.8*	*-1.0*
OM_PI (std)	*0.7*	*0.0*	*-2.2*	*0.8*	*-0.8*
OM_BIKE	2	2	0	5	1
OM_MOTO	1	1	0	1	0
OM_CARDR	6	11	12	10	11
OM_CARPAX	7	4	5	4	3
OM_BUS	13	5	1	7	1
OM_TRAM	4	1	0	5	1
OM_METRO	13	5	0	10	3
OM_TAXI	1	0	0	1	0
OM_SUBURB	4	1	0	1	0
OM_TRAIN	2	1	0	2	1
SWITCH_GLOB (std)	*0.7*	*0.4*	*0.5*	*-1.2*	*-1.5*
SWITCH_BUS_L	3	3	3	1	1
SWITCH_BUS_H	5	4	4	2	1
SWITCH_DRTS_L	4	3	3	1	1
SWITCH_DRTS_H	5	4	5	1	1
SWITCH_TAXI	3	3	2	1	1
SWITCH_CARPOOL	9	7	7	3	2
Number of observations	34	70	14	27	19
%	21	43	9	16	12

Also these clusters could be targeted with different actions aimed at promoting more sustainable travel behaviours. On the basis of their socioeconomic characterisations, summarised in Table 6, the following actions could be envisaged:

- *1) Multimodal public transport heavy travellers, interested in new modes*: Given the higher than average mobility levels of this group, the implementation of travel reduction strategies (e.g. a personalized travel planner to optimize trips and activity patters) could be an effective tool. Furthermore, the strong multimodal habits of this group could be reinforced by improving interchange points across different travel modes or services, such as park and ride facilities or the possibility of carrying bicycles onboard public transport vehicles. This groups shows also very positive attitudes towards carpools.
- *2) Car-dominated light travellers, carpool interested*: Suitable cluster to apply persuasive messages promoting the positive aspects of using diverse transit modes, while raising the awareness on the negative externalities of the automobile. Suitable market segment to encourage the carpooling service given their moderately positive

attitude towards this mode; moreover, almost all individuals in this group own at least one car and consequently their automobiles could be shared with other individuals.

- *3) Monomodal light travellers, interested in new modes*: Travel demand strategies implemented for this group should be very similar to those for the previous one, although public transport seems not a viable option in this case.
- *4) Multimodal heavy travellers, not interested in new modes*: Travel reduction strategies can be exploited given the higher than average mobility levels. Concerning the actions to promote modal diversion, this group is not willing to try new transport services but is using existing ones, especially metros and buses: therefore, improving the offer of existing public transport seems a promising avenue.
- *5) Car-dominated light travellers, not interested in new modes*: Modal diversion seems hardly achievable for this group. On the other hand, mobility levels are lower than the average, so raising the awareness on the environmental costs of driving a car seems the only viable option.

Table 6. Socioeconomic characterisation of individual-level multimodality clusters

Variable	1) Multimodal public transport heavy travellers, interested in new modes	2) Car-dominated light travellers, carpool interested	3) Monomodal light travellers, interested in new modes	4) Multimodal heavy travellers, not interested in new modes	5) Car-dominated light travellers, not interested in new modes
% females	64.7%	47.1%	57.1%	33.3%	63.1%
Number of people in the hh	2.38	2.67	2.85	3.04	2.53
% hh annual income < 25000 €	42.4%	28.6%	41.7%	25.9%	50.0%
% hh annual income > 60000 €	15.2%	14.3%	0	11.1%	16.7%
Number of cars in the household	1.00	1.38	1.50	1.15	1.58

4.3. Comparing trip-level and individual-level multimodality clusters

The two previous subsections have presented two different cluster analyses, aimed at characterizing groups of travellers on the basis of their multimodality habits and attitudes, by either considering attitudes and behaviours related to a randomly chosen trip or their more general travel behaviours. The resulting classification schemes are now compared in Table 7, in order to assess to which extent they show consistent results. Pairs of cluster found on the same line of the table are deemed comparable, according to the analysis of the traveller profiles that is detailed in the last column.

In general terms, it can be seen that there is a good matching between the two sets of clusters. The first three lines of Table 7 show three groups of travellers that have higher potential to lower the environmental footprint of their travel patterns. On the other hand, trip-level analysis identified a fourth group that is less prone in doing so. The same segment is somewhat found also in the personal-level analysis, although an additional group (number 4) was discerned where multimodality practices are present, but the interest in trying new means is low.

5. Conclusions

This paper has presented some traveller profiling analyses based on multimodality behaviours with reference to both a specific trip and the general level of mobility through different transport means. Four different market segments were extracted from the first market segmentation regarding the surveyed trip, while five different clusters were found from the market segmentation concerning multimodality in all types of trips and the individuals' propensity to switch to the proposed services.

These clusters in both cases provide useful and consistent information for policy makers and stakeholders interested to reduce excessive car use and promote new transport services. Complementary policy indications emerged compared to past market segmentation studies in the transport sector, since both stated and revealed preferences related to multimodality issues allow for a new classification of travellers that brings into light different

ways of matching personal characteristics and policy options. The best ambits of use of some policy options can be summarized as follows:

- *High quality bus services* seem to have a limited appeal for the identified segments, but are in any case preferable compared to new cheaper but slower bus services. Preference patterns for demand responsive services are rather comparable.
- *Carpooling* by contrast seems to raise much more interest, both from individuals that almost exclusively drive cars and by some of the actual customers of public transport. This seems therefore the service with highest potential to achieve modal diversion.
- *Multimodal interchange facilities* such as park and ride schemes or carrying bicycles on public transport means are important to reinforce multimodal behaviours of the fraction of population that is already combining different travel modes.
- *Voluntary travel behaviour change programs* seem particularly useful for specific groups of travellers that show wider gaps between general positive attitudes towards modal diversion and intentions related to the trips that they concretely take.
- *Advertising campaigns* showing the drawbacks of car use can be seen as a last resort for the population segment that almost exclusively drives a car and is not showing any interest in changing their behaviour. Rather than directly promoting the use of alternative modes, raising awareness on the amount of trips that are performed and providing suggestions on how to reduce them through a *personalized travel planner* could be an option.

Future work will build on those results to inform a behavioural model that will better clarify the relationship between multimodality habits and attitudes and the maximum possible extent of modal diversion and decrease of use of motorized individual transport means.

Table 7. Summary of the comparative analysis between clusters

Trip-level cluster	Corresponding individual-level cluster	Remarkable similarities
A) Low multimodal, open to change	2) Car-dominated light travellers, carpool interested	1) Almost same size (46% and 43% of the sample) 2) Regular use of automobile 3) Little use of bus 4) Little use of metro 5) Practically same propensity to switch to the new modes (Positive propensity to switch to the carpool service) 6) Almost same socioeconomic characteristics 7) Practically same characteristics regarding the random trip.
B) Car monomodalists, eager to change	3) Monomodal light travellers, interested in new modes	1) Similar size (4% and 9% of the sample) 2) Great use of the automobile 3) Similar positive propensity to switch to the carpool service. 4) Similar in some socioeconomic characteristics (n° of cars, zone of residence) 5) Number of mechanised modes utilized in the random trip.
C) Multimodal, carpool interested	1) Multimodal public transport heavy travellers, interested in new modes	1) More or less similar size (28% and 21% of the sample) 2) Great use of diverse transport means 3) Similar positive propensity to switch to the carpool service. 4) Similar in some socioeconomic characteristics (income, zone of residence)
D) Low multimodal creatures of habit	5) Car-dominated light travellers, not interested in new modes	1) Regular use of automobile 2) Little use of alternative modes 3) Negative propensity to switch to all the new proposed modes. 4) Similar in some socioeconomic characteristics (n° of cars, n° of persons in households, zone of residence) 5) Number of mechanised modes utilized in the random trip.
(no corresponding trip-level cluster)	4) Multimodal heavy travellers, not interested in new modes	-

Acknowledgements

An earlier version of this paper has been revised in light of the constructive comments of two anonymous referees.

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