Effect of travel behaviour change programs on time allocated to driving

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Since part of car dependency is stemmed from personal choices of car over other modes of transportation, technological solutions are not the only way to reduce car use. Travel Behaviour Change Programs (TBCP) are significantly cheaper transportation policy measures, which have evolved in order to shift people voluntarily out of their cars and into public transportation or non-polluting modes of travel, such as walking or cycling. Recently, a two-wave activity scheduling process panel survey was conducted over a period of two years in the city of Valencia (Spain). Part of the respondents received a set of TBCP between both survey waves. We have used double censored Tobit models to assess the effect of the TBCP on time allocation to driving a car or a motorbike. Results show that participation in the TBCP is significantly positive to reduce car or motorbike use, and its effectiveness is affected by different socioeconomic factors.

Keywords: Activity Scheduling Process, Panel Survey, Travel Behavior Change Programs, Car Driving, Tobit Model

1. Introduction

Excessive reliance on private automobile for daily travel is currently the most consistent reason of increasing traffic congestion, emission and air pollution in most cities (Bamberg and Schmidt 2003). One of the many reasons of such car-dependency is the mobility benefits that a car provides to individuals and families. However, such mobility freedom comes with tremendous costs of externalities and eventually increasing traffic congestion and reducing mobility. For the last decades, a large number of policy measures to reduce car use have been available to transport planners. Commonly known as “travel demand management” (TDM) (Kitamura *et al.* 1997, Pas 1995), are divided into “hard” and “soft” measures. “Hard” measures include improvements to the public transport infrastructure, increased costs for car-use and control of road space. Although these measures are sometimes necessary to achieve car-use reductions, they are difficult to implement because of public opposition and political

infeasibility (Jones 2003, Gärling and Schuitema 2007) and their impact may show relatively small and fairly short-lived effects if applied alone (Stopher 2004, Moser and Bamberg 2008). In contrast to these "hard" measures, TDM literature include many other "soft" measures: encouraging modal shift, reducing the negative impact of the car, reducing demand for the car, encouraging more efficient use of the transport system, reducing congestion and encouraging behaviour change of the individual (Roby 2010). Effectiveness of these "soft" measures has been deeply analysed (Goodwin et al 2004, Cairns *et al.* 2004, Goodwin 2008, Eriksson 2009, Loukopoulos *et al.* 2004, Shiftan and Suhrbier 2002). Many researchers agree that finding synergies between "soft" and "hard" transport policy measures would reap the maximum benefits (Steg and Schuitema 2007, Jones 2003, Gärling and Schuitema 2007, Thorpe *et al.* 2000, Cairns *et al.* 2008, Moser and Bamberg 2008, Richter *et al.* 2011, Givoni and Banister 2013, Kopp *et al.* 2013, World Bank 2011).

Several "soft" transportation policy measures have arisen in order to get better cost-effective results in delivering shifts from car to public transportation or non-polluting modes of travel, such as walking or cycling. Examples of these "soft" measures are the Travel Behaviour Change Programs (TBCP) -also known as Voluntary Travel Behaviour Change (VTBC) programs, Sustainable Travel Plans or simply Smarter Choices- which are carried out to motivate people to reduce their car use, specifically single-occupant trips. Several benefits to both society and individuals (when car is replaced by walking or riding a bicycle) have been proved. Those programs include personal travel scheduling, travel awareness campaigns, workplace or study place travel plans and strategies like car sharing (Brog *et al.* 2009, Chatterjee and Bonsall 2009, Moser and Bamberg 2008, Bamberg *et al.* 2011, Cairns *et al.* 2008).

Some recent studies focus on measures to increase children's walking and cycling (Mackett 2013, Van Goeverden and de Boer 2013).

Measures usually included in the TBCP are related to providing better information on transportation options, appropriate assistance, motivation or incentives, rather than through investments in public transportation, or through disincentive programmes for the car (Stopher and Bullock 2003, Chatterjee and Bonsall 2009). Two popular and widespread TBCP are Travel Blending® and Indimark®, which are quite similar in some aspects but also different in others. Indimark® (Brög and Schadler 1998) tries to set out individualized marketing of public transportation, walking, and cycling to individuals by providing tailored information. On the other hand, Travel Blending® attempts to raise awareness on people on their travel patterns and then offering viable changes to reduce possible unnecessary or wasteful travelling. In fact, the authors point out that the best results tend to occur when participants can see or expect to find other personal benefits of direct significance to themselves, such as more quality time with family and friends, etc. (Rose and Ampt 2001).

TBCP have been frequently applied in the past decade. Examples are in Australia (Taylor 2007), the UK (Cairns *et al.* 2008), Sweden (Friman *et al.* 2013), Germany and Austria (Ker 2003), Italy (Meloni *et al.* 2013), the Netherlands, the USA (Richter *et al.* 2010) and Japan (Fujii and Taniguchi 2006). However, the methods used to evaluate their effectiveness still raise debates among the professionals and researchers (Stopher *et al.* 2007, Stopher and Greaves 2007, Stopher and Swann 2007, Taylor 2007, Bonsall 2009, Chatterjee 2009, Chatterjee and Bonsall 2009, Cohen 2009, Philp and Taylor 2010, Richter *et al.* 2011). Initially, some programs used research techniques that did not allow statistical inferences to be drawn from their results. Particularly, many program designs lack adequate control groups to evaluate travel

behaviour change. Failure to select a control group appropriately may take it impossible to determine if there are underlying travel behaviour changes that need to be factored into the changes measured within the target population. Control groups should be a subset of the same population as the sample, facing identical transport options and encountering the same external pressures of changes in the socio-political landscape that could affect travel; and they should provide an indication of how target individuals/households would have behaved in the absence of a TBCP (Stopher *et al.* 2009). In case there is no control group, program designs just use pre- and post-tests of participants behaviour, which cannot exclude the influence of changes in travel behaviour that may occur within the general population, for example due to changes in season, travel or fuel costs, public transportation service, or roadway construction (Moser and Bamberg 2008, Fujii *et al.* 2009).

Socialdata America (2007) and Brög *et al.* (2009) reviewed the studies on the TBCP applications that included control groups in their evaluations. In addition, the meta-analysis of Moser and Bamberg (2008) attempted to address some of the methodological shortcomings of earlier evaluations by examining pooled effect sizes. Results from the Sloman *et al.* (2010) evaluation and Moser and Bamberg (2008) meta-analysis appear to indicate that the TBCP effects persist when self-selection is accounted for, though the effects may be somewhat smaller. These studies found driving trip reductions of 3 to 11 percent observed after 3 to 24 months after the application of TBCP.

An important question addressed by researchers in the last years is whether travel behaviour changes produced by the TBCP are maintained in time or not (Taylor and Ampt 2003, Stopher *et al.* 2004, Bonsall 2009, Chatterjee 2009, Seethaler and Rose 2009, Stopher *et al.* 2009). Researchers define as immediate or short-term effects those

observed a few weeks/months after the development of the programs. Medium-term effects correspond to changes observed over 6 months after TBCP (Tørnblad et al 2014) whereas long-term effects are those observed at least 12 months after TBCP (Müller-Riemenschneider et al 2008). Most studies report short and medium-term effectiveness, while only a few of them get to report results after a year (John 2001, Marinelli and Roth 2002, Taniguchi *et al.* 2003, Matsumura 2004, Socialdata 2004, Seethaler and Rose 2009). An interesting approach into the longevity of the effects is given by Zhang *et al.* (2013), who points out that if TBCP get to "change attitudes as well as behaviours, there is a much greater likelihood that the behaviour changes will be sustained".

Most of the TBCP applications have been based on two psychological theories: the Theory of Planned Behaviour (TPB) (Ajzen 1985, 1991) and the Norm-activation Theory (Schwartz 1977). Many other theories are based on the former. For example, Heath and Gifford (2002) extended the TPB to predict and explain public transportation use. Bamberg *et al.* (2007) and Bamberg and Möser (2007) proposed a joint theory based on the previous theories, adding some elements from informational social influence theories (Moscovici 1985). Recently, Bamberg *et al.* (2011) proposed and tested a self-regulatory theory of travel change, integrating elements from the joint theory and applying concepts from control theory (Gärling *et al.* 2002, Loukopoulos *et al.* 2007).

Considering that the influence of knowledge and/or attitudes rarely lead directly to behavioural changes (Anable *et al.* 2006), we studied other behavioural factors (social and situational factors at a variety of social levels) that may act as barriers to changes. Thus, we adopted Ken Wilber's four-quadrant structure (2000), which classifies barriers to behavioural change at the personal or at the collective level, and may consist of either subjective or objective factors. In particular, we focused on

evaluating individual subjective barriers to define and apply actions capable of overcoming them.

On the other hand, research in the domain of public health, energy consumption, waste management, etc. have shown that information-based campaigns, including the use of incentives, are mostly insufficient for stimulating behavioural change of lasting effect (Hines *et al.* 1987, Hornik *et al.* 1995, Hodgson *et al.* 1997, Tertoolen *et al.* 1998, Jopson 2000, Seethaler and Rose 2003). In this context, we decided to use some persuasion techniques from social psychology, which are equally suitable for private sector marketing as for community based social marketing strategies and that are able to reach beyond the mere raising of awareness (Cialdini 2001).

The aim of this paper is to assess the effect of the TBCP on the observed car and motorbike use by using data from the second survey wave of an activity scheduling process panel survey. In this survey, approximately 62 per cent of all panellists (respondents who gave information in both survey waves) participated in the TBCP. Private vehicle (PV) use is measured by the proportion of daily time allocated to driving to the total daily time allocated to travelling. For this objective to be met, the effect of several individual and family characteristics on this proportion is researched by using a doubled censored Tobit model.

The rest of the paper is organized as follows. Characteristics of the dataset used are presented in the next section. This section is followed by an explanation of the methods and empirical results. The paper ends with some conclusions and discussion.

1.1.Activity Scheduling Process Panel Survey

A two wave activity scheduling process panel survey was conducted over a two-year period in the city of Valencia (Spain). The main purposes of this panel survey were to achieve a better knowledge of the travelling mode choice in urban areas and to study the

potential effect of the Travel Behaviour Change Programs (TBCP) on activity-travel scheduling process decisions. First and second wave took place during autumn of 2010 and autumn of 2011 respectively. Only 62% of the respondents who were surveyed on both survey waves participated in the TBCP that took place between both waves.

Both survey waves consisted of three phases. First phase was a preliminary face-to-face interview where respondents were asked to generate, using paper and pencil, a pre-planned activity–travel agenda for the following week starting the day after the interview. Respondents should define all activities and trips already decided to be carried out, giving as many details as possible. Demographic and socioeconomic information was collected as well. Before ending the interview, respondents received a mobile phone with an activity-travel diary implemented on to collect activities and trips as they were executed and a cash incentive (30 euro) for the second phase.

Second phase was developed during the research week, since respondents had to carry on with them the mobile devices and complete the activity-travel diary to collect characteristics (initial time, duration, location, etc.) of activities and trips as executed. Unlike other Personalized Travel Planning (PTP) measures that use traditional paper activity travel diaries at the end of the day, the activity-travel diary implemented on a mobile device and completed in real time ensures faster data processing and lower rate of missing data. Information was sent in real time to the research group, who compared pre-planned agenda and observed activities and trips. Third phase consisted in an innovative in-depth telephone interview. Participants were contacted by phone two or three times during the research week to inquire them about the reasons of differences observed between pre-planned and executed activities and trips. Contacts also let us to confirm that all the information gathered was accurate, correcting any possible mistake made by respondents during diary completion.

In 2009, a previous survey was conducted in the city of Valencia (Spain) to study willingness to change from car and public transportation to non-motorized travel modes (Ruiz and Bernabé 2014). Potential respondents were approached at parking lots located throughout the city when they were going to start their journey back home in the evening. 787 of them admitted using car for most of their journeys and accepted to fulfill the questionnaire. 492 out of 787 accepted to participate in a subsequent research survey (the two-wave panel survey mentioned above and used in this study) and were contacted by phone a year later to ask for their participation. Finally, 165 of them provided complete information in the first wave, which means 33.5% of those who initially indicated their disposition to participate.

Between both waves, 47 respondents abandoned the panel due to change of residence outside the study area, transfers abroad for work or simply decisions not to continue, so attrition rate was 28.5%. Therefore, 118 individuals participated in both survey waves, so final response rate was 24%. In order to complete sample size in the second wave, the remaining respondents were asked to inform on their friends, family and colleagues who would be interested in participating. New respondents were selected so as to be as similar as possible to those who left, in terms of demographic and socioeconomic characteristics. Finally, in the second wave there were 166 respondents who carried out the activity-travel scheduling process survey.

Table 1 show that demographics and socioeconomics were similar in both waves. As it can be observed, the sample of people older than 60 is very small in the first wave and is non-existent in the second wave. This is because during the research week the respondents were asked to introduce a lot of data in the activity-travel agenda implemented in the mobile device, and it was a bit difficult for the research group to find people older than 60 willing to complete this task during a week. On the other

hand, small differences in gender allocation can be observed between participants and non-participants in the TBCP.

Table 1. Sample Demographic and Socioeconomic Distribution

	1st wave	*2nd wave*	Panellists	TBCP	CG
Women	49.1%	51.2%	49.6%	43.1%	58.1%
Men	50.9%	48.5%	50.4%	56.9%	41.9%
Employed	69.8%	65.5%	70.1%	69.4%	62.4%
Students	24.6%	23.6%	20.5%	20.8%	25.8%
Other	5.6%	10.9%	9.4%	9.7%	11.8%
Aged <30	37.4%	42.4%	38.5%	38.9%	45.2%
Aged 30-39	32.4%	30.3%	33.3%	30.6%	30.1%
Aged 40-49	17.9%	16.4%	17.9%	18.1%	15.1%
Aged 50-59	10.6%	10.9%	10.3%	12.5%	9.7%
Aged 60+	1.7%	0.0%	0.0%	0.0%	0.0%

1.2.Travel Behaviour Change Programs

After the first survey wave, a short questionnaire with 12 questions was elaborated and sent to all panellists in order to identify their psychological internal barriers to modify travel behaviour. These barriers apply at the personal or at the collective level and may consist of either subjective or objective factors. We used those defined in Ken Wilber's (Wilber 2000) four-quadrant structure as a starting point and focused mainly on individual subjective factors. Different question formats were used depending on the type of information to be collected. An example of each question format is shown in Table 2. Likert scales were used to evaluate perceived behavioural control asking respondents how feasible was for them to perform specific travel behaviour changes (e.g. Question 1). Affective attitudes towards car and alternative travel modes was also studied using Likert scales asking respondents to indicate their level of agreement to predetermined adjective description of each travel mode (e.g. Question 2). Instrumental attitudes towards car and alternative travel modes were collected using multiple

response questions (e.g. Question 3). Self-identity and status was evaluated asking respondents what was the difference between them and transit/bicycle users or walkers (e.g. Question 4). Response rate was 89.8 percent.

Table 2. Examples of questions in the questionnaire of psychological internal barriers

Question 1: How feasible is for you to perform the following travel behavior changes? (0="No, I can't change at all"; 5="Yes, I definitely can change")

- Drive less and use PT more
- Drive less and to walk more
- Drive less and use bike more
- Reduce number of travels

Question 2: Indicate your level of agreement with the following sentences (0=fully disagree; 5=fully agree)

- Car is a comfortable transport mode
- Car adapts to my travel needs perfectly
- Using car lets me more mobility freedom
- I like driving
- Using car increases privacy
- Car is a secure transport mode
- Using car is relaxing
- Car is a safe transport mode

Question 3: Consider a change in your travel behavior. Which sentence(s) is close to your case?

- Travelling by PT will take me a long time
- It is too far away for biking/walking
- An hybrid/electric car is too expensive
- My current job impedes me to change
- My timetable impedes me to share car
- There are not PT services that fit my needs

Question 4: What is the difference between a bike user and you?

- They are healthier
- No difference at all
- They usually travel shorter distance
- They are more environmental concerned
- They have a flexible job dress code
- They have bike shed at home
- They are brave
- They have more time available
- I'd like to be a cyclist

Actions to be included in the TBCP were designed based on the results obtained from the questionnaire. Three different actions based on psychological principles of persuasion (Cialdini 1984) were designed. First action was defined to cope with barriers related to perceived behavioural control and instrumental attitudes applying persuasion principles of reciprocity and scarcity. On the one hand, those respondents who declared a low perceived behaviour control towards the use of transit received personalized journey planning. Respondents' mobility was analyzed and recurring trips were identified. Once we knew characteristics as origin, destination, timing and companion of the most recurring trip, we looked for a more sustainable travel alternative (mainly by bus and/or subway, but sometimes defining multi-mode trips including walking or riding a bicycle). If it was not possible to find an alternative to car for the most recurring trip, then we selected other recurring trip. Parameters as annual savings, the annual reduction of car-related pollution and travel time were considered. A report with all this information together with general information (bus and subway stops, schedules, fares, etc.) of transit supply available in their neighborhoods was sent to each respondent by post. This intervention was created considering that we had a sample of habitual drivers who do not usually use public transport (or do not usually make journeys on foot or by bicycle), and they have a perception of those modes alternatives to car that is worse than the actual "service level" (Anable *et al.* 2006). On the other hand, a second report with information about health benefits of walking and riding a bicycle together with bad effects of long-term use of car was sent to those respondents who also showed negative instrumental attitudes.

Second action was defined to contend with barriers related to self-identity and status. Thus, we applied the persuasion principle of authority to influence those respondents who described walkers and bicycle users as healthier people. They were

invited to attend a talk given by a cardiologist and a sport trainer on the relation between health and physical activity and how walking and riding a bicycle can improve their health.

Finally, third action was defined to deal with barriers related to affective attitudes. We applied the persuasion principles of social proof and liking to those respondents who exposed negative feelings associated to alternative transportation modes. They were invited to watch a video session where people who recently had reduced the use of the car were interviewed on the street on why they had decided to do so (Ruiz and García-Garcés 2015). Some quotes of the answers are presented below:

- "Four years ago I gave up driving and started making my trips walking or riding a bicycle because it's more comfortable, I do some physical exercise and I save money" "I wouldn't go back to driving my car every day… driving in Valencia is quite uncomfortable!"
- "Riding my bicycle isn't a problem to pick up my children because they have also their own bicycle and we go back home together" "I think the bicycle allows me to move easily and quickly, without concerns about where to park the car"
- "Since I began riding my bicycle to commute, I didn't need to go to the gym or go out running to do some exercise. Besides, I find it relaxing and let me saving money"
- "When I retired, I began to go everywhere by bus. The different routes available offer me freedom of movement though Valencia. I also try to walk because it helps me to not getting fat"
- "When it's cold I still use my car, but when the weather is better I prefer riding a public bicycle. I find it cheaper and more comfortable"

- "I like the bicycle because I arrive to my workplace in a better mood. It isn't as quick as other modes but I think it is worth. Unless it rains, I use the bicycle"
- "I gave up driving because I used to lose many time driving in the rush hour and looking for a parking. Now, commuting by bus is easier, cheaper and more environmental-friendly"
- "I prefer using public transport because of my moral code. I know that if I use the bus or the tram then I'm not contributing to traffic jams and pollution"

72 out of 117 panellists (one panellist was discarded due to his new employment as driver in the second survey wave) participated in the TBCP, whereas the rest were included in the Control Group (CG). At least two of the previous actions were applied to each participant in the TBCP to motivate them to reduce their car use and utilize alternative travel modes.

Control Group composition was defined so that both control and treatment groups resulted in a similar demographic and socioeconomic distribution. CG was composed of 45 respondents: 33 panellists who completed and sent back the psychological barriers questionnaire, and 12 panellists who did not complete the questionnaire (Ruiz and García-Garcés 2015). In this analysis, Control Group has been expanded to include second wave new recruits (48 respondents), given that they did not participate in the TBCP either.

1.3.Dataset for empirical research

Both survey waves provided a rich source of detailed information on scheduling, rescheduling and executing daily activities and trips. In this study only execution decisions collected in the second wave were analyzed, which were a total of 18,606

executed activity-travel episodes provided by 165 respondents.

To assess the effect of the TBCP on daily time allocated to driving, 4,633 executed travel episodes with a duration lower than 60 minutes were analyzed. Travel episodes with longer durations have been discarded in order to avoid the impact of extraordinary long trips outside the studied area. After excluding those travel episodes, the average length of the trips in the first wave is 18 minutes and 45 seconds, while in the second wave it was 19 minutes and 38 seconds.

The most used transportation mode is PV (car and motorbike users; 3,445 episodes), followed by walking (859 episodes). On the other hand, public transportation (192 episodes) and cycling (137 episodes) are less used. Those travel episodes have been gathered per person per day, a total of 1,155 days for 165 participants. To analyze the proportion of daily time allocated to driving to the total daily travel time correctly and given that all persuasion actions encouraged travel mode switch instead of reducing the need for travel, those days without any travel episode were discarded, therefore the final dataset comprises the travel data of 1,091 days.

2. Analysis and results

2.1.Dependent and explanatory variables

Most of the observed trips per day were carried out by car, as all participants where habitual drivers. The level of use of PV in wave 2 has been measured by considering the daily time allocated to use PV in relation to the total daily time allocated to travel per person. Consequently, the dependent variable is the proportion:

Time allocated to travel in private vehicle/Time allocated to travel

The dependent variable is a continuous variable which always takes values between 0 and 1. Explanatory variables include features of the time allocated to travelling, number of trips per day, individual and family characteristics and their willingness to change towards more sustainable travel habits (Table 3).

Table 3. Dependent and Explanatory Variables

VARIABLE	DEFINITION
Dependent variables	
RATIO	Ratio: (time allocated to PV) divided by (total time allocated to travel)
Explanatory variables	
Travel attributes	
TOTALTIME	Total time allocated to travel episodes (in hours)
PRIVEHTIME	Time allocated to travel in PV (in hours)
TOTALTRIPS	Total number of trips
PRIVEHTRIPS	Number of trips in PV
Individual attributes	
Survey attributes	
PANEL	1=Respondent participated in both waves; 0=otherwise
TBCP	1=Respondent received personal TBCP; 0=otherwise
Age attributes	
YOUNG	1= Respondent age is between 18 and 30; 0= otherwise
ADULT	1= Respondent age is between 31 and 50; 0= otherwise
SENIOR	1= Respondent age is over 50; 0= otherwise
Gender attribute	
GENDER	1= Female ; 0= Male
Marital status	
DIVORCED	1= Respondent is divorced ; 0= otherwise
MARRIED	1= Respondent is married ; 0= otherwise
COUPLE	1= Respondent lives in couple but not married (co-habiting couple); 0= otherwise
SINGLE	1= Respondent is single ; 0= otherwise
Education level	
PRIMARY	1= Primary school is the higher level of education for respondent ; 0= otherwise
SECONDARY	1= Secondary school is the higher level of education for respondent ; 0= otherwise
HIGHER	1= Respondent has studied non-university higher education/professional school/further education; 0= otherwise
DEGREE	1= Respondent has studied a degree ; 0= otherwise
MASTER	1= Respondent has studied a master's degree ; 0= otherwise
Labor status	
STUDENT	1= Respondent is studying ; 0= otherwise

EMPLOYED	1= Respondent is employed ; 0= otherwise
RETIRED	1= Respondent is retired ; 0= otherwise
UNEMPLOYED	1= Respondent is unemployed ; 0= otherwise
Willingness to change	
WILLING	1=Respondent is willing to change his/her mobility towards a decrease of car use; 0=otherwise
Family attributes	
Household attributes	
HMEMBERS	Number of members at home (including respondent)
SHARED	1= Respondent lives in a shared house ; 0= otherwise
HEAD	1= Respondent lives alone, lives only with his/her partner or is one of the parents in case the household is inhabited by a family ; 0= otherwise
CHILD	1= Respondent lives with his/her parents ; 0= otherwise
FAMWEEKDAY	1= Respondent lives with his/her family during weekdays ; 0= otherwise
FAMWEEKEND	1= Respondent lives with his/her family during weekends ; 0= otherwise
Mobility	
CAR	Number of cars per household
MOTORBIKE	Number of motorbikes per household
BIKE	Number of bikes per household
CARAVA	2=High car availability (every day in the week); 1=Medium car availability (3-6 days per week); 0=Low car availability (2 days per week or less)

2.2.Descriptive analysis

The proportion of time allocated to travel by PV has decreased in general between the two waves (Table 4). However, the decrease has been higher in the case of TBCP participants in comparison with non-participants. Regarding the average proportion per person-day in the second wave, it can be observed that men used PV more than women, people aged between 31 and 50 used PV more than younger or older participants, as well as divorced people used PV more than married, singled or people living in couple. According to family attributes, those people who are head of their household show a higher average proportion than those who live with their parents or share a house. Besides, people who stated not living with their family during the week also show a higher average proportion. According to education level, the highest proportion is associated to people with primary or non-university higher education as academic

background. On the other hand, people who had a master's degree show the lowest average proportion. Logically, those respondents whose car availability was high during the week or are not willing to reduce car use also show a higher average proportion. Finally, according to labor status, employed people show the highest average proportion while students show the lowest.

Table 4. Average ratio per person-day

	Time in PV/ Total travel time	
	1st wave	2nd wave
New recruit (No panelist)	0.814	0.789
Panelist	0.831	0.802
Control group	0.818	0.807
TBCP participant	0.833	0.787
Male	0.839	0.800
Female	0.811	0.796
Young	0.828	0.796
Adult	0.830	0.815
Senior	0.784	0.732
Married	0.817	0.780
Divorced	0.947	0.933
Coupled	0.873	0.810
Single	0.813	0.795
Head	0.829	0.806
Shared	0.854	0.781
Child	0.814	0.794
Weekday no	0.830	0.826
Weekday yes	0.825	0.794
Weekend no	0.821	0.803
Weekend yes	0.826	0.797
Primary	0.916	0.835
Secondary	0.861	0.789
Higher	0.835	0.837
Degree	0.776	0.803
Master's	0.806	0.768
Low car availability	0.159	0.392
Medium car availability	0.702	0.631
High car availability	0.840	0.830
Unwilling	0.892	0.824
Willing	0.816	0.789
Unemployed	0.766	0.807

Studying	0.813	0.752
Working	0.835	0.814
Retired	0.737	0.775

Table 5 shows, for each variable, the average daily proportion of time allocated to travelling by PV to the total daily travel time, both for respondents in the CG and for participants in the TBCP. Independent samples t-tests are used to compare the average proportion values for participants in the TBCP and non-participants. The objective is to test the null hypothesis that the difference between those two related means is 0. The t-test assumes that the variability of each group is approximately equal. Without that assumption, a special form of the t-test should be used. So, Levene's Test for Equality of Variances is used (Levene 1960).

The average proportion is significantly lower in the TBCP group for those participants aged between 31 and 50, those who are the head of their households, those living with their family during weekdays, those who have studied non-university higher education, those who have a high availability of the car, and those who are unemployed. On the other hand, the proportion is significantly lower in Control Group for women, students, and those who have primary studies.

Table 5. Time in PV/Total travel time. Independent Samples t-tests

	Time in PV/Total travel time		Levene's Test for Equality of Variances			t-test for Equality of Means		
	CG	**TBCP**	**F**	**Sig.**		**t**	**df**	**Sig (2-tailed)**
Male	0.822	0.779	6.849	0.011	**	1.269	71.671	0.208
Female	0.796	0.797	13.973	0.000	**	1.981	81.834	0.051
Young	0.799	0.791	10.032	0.002	**	1.636	70.076	0.106
Adult	0.837	0.787	19.142	0.000	**	2.050	69.216	0.044
Senior	0.682	0.771	13.720	0.002	**	-1.512	8.000	0.169
Married	0.801	0.760	12.222	0.001	**	1.654	57.613	0.104
Divorced	0.931	0.936	0.583	0.470	*	0.424	7.000	0.685
Coupled	0.819	0.786	4.295	0.054	**	1.472	13.000	0.165

Single	0.789	0.804	2.064	0.155	*	0.703	67.000	0.484
Spouse	0.826	0.782	11.945	0.001	**	1.666	84.321	0.099
Shared	0.828	0.707	2.826	0.106	*	0.784	24.000	0.440
Child	0.766	0.836	4.052	0.050	**	1.035	47.979	0.306
Famweek no	0.877	0.753	3.246	0.087	**	1.000	12.000	0.337
Famweek yes	0.796	0.792	13.270	0.000	**	1.793	140.388	0.075
Famwend no	0.841	0.752	7.949	0.008	**	1.455	18.000	0.163
Famwend yes	0.798	0.795	10.535	0.001	**	1.601	129.884	0.112
Primary	0.826	0.877	15.120	0.002	**	2.309	12.000	0.040
Secondary	0.778	0.802	2.297	0.138	*	0.736	36.000	0.467
Higher	0.857	0.788	31.429	0.000	**	2.582	16.000	0.020
Degree	0.793	0.810	2.688	0.112	*	-0.776	28.000	0.444
Master's	0.789	0.745	0.978	0.327	*	0.489	53.000	0.627
Low car availability	0.362	0.454	.	.	*	.	1.000	.
Medium car availability	0.632	0.629	2.499	0.131	*	0.725	18.000	0.478
High car availability	0.848	0.809	14.982	0.000	**	1.892	137.931	0.061
Unwilling	0.806	0.853	5.630	0.024	**	1.129	30.126	0.268
Willing	0.806	0.770	7.593	0.007	**	1.372	123.945	0.173
Unemployed	0.817	0.787	22.750	0.000	**	1.964	9.000	0.081
Studying	0.730	0.788	11.068	0.002	**	1.813	23.000	0.083
Working	0.839	0.786	7.313	0.008	**	1.332	104.629	0.186
Retired	0.720	0.803	.	.	*	-0.577	1.000	0.667

*Equal variances assumed/ **Equal variances not assumed

2.3.Empirical Models

The Tobit model or censored normal regression model is useful for analyzing the relationship between a non-negative dependent variable y_i and an independent variable or vector x_i. A Tobit model is an econometric model in which the dependent variable is censored for some reason, i.e., because values below zero are not observed. The Tobit model assumes that there is a latent unobservable variable y_i^*. This variable is linearly dependent on the x_i variables via a vector of β_i coefficients that determine their interrelationships. In addition, there is a normally distributed error term ϵ_i to capture random influences on this relationship. The observable variable y_i is defined to be equal to the latent variables whenever the latent variables are above zero and y_i is assumed to be zero otherwise. (Greene 2003) That is,

$$y_i^* = \beta' x_i + \epsilon_i \quad (1)$$

$$y_i = 0 \text{ if } y_i^* \leq 0 \quad (2)$$

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

As previously explained, the dependent variable in this study is a continuous variable which always takes values between 0 and 1. This variable exhibits relatively large numbers of observations at both zero and 1 extremes of the possible range values, implying double truncation. The two-limit Tobit model is well-suited to such data. Therefore, the Tobit used in this study includes censoring both distribution tails, so the function is,

$$y_i^* = \beta' x_i + \epsilon_i \quad (4)$$

$$y_i = 0 \text{ if } y_i^* \leq 0 \quad (5)$$

$$y_i = y_i^* \text{ if } 0 < y_i^* < 1 \quad (6)$$

$$y_i = 1 \text{ if } y_i^* \geq 1 \quad (7)$$

where $\epsilon_i | x \sim N[0, \sigma 2]$

The marginal effects in the Tobit model are computed using

$$\partial E[y|x]/\partial x = \Phi((\beta' x)/\sigma)\beta \quad (8)$$

To estimate the parameters of proposed models Maximum Likelihood method is used. Nlogit[1] software was used to this end.

[1] NLOGIT is available from Econometric Software (http://www.limdep.com/).

2.4.Models 1, 2 and 3: Analysis of the proportion of time allocated to travelling by PV to the total travel time

Model 1 is used to identify factors influencing the proportion of time allocated to travelling by PV to the total travel time. Among these factors we include the participation in TBCP, which we hypothesized to negatively affect the proportion, therefore reducing car use. Positive signs of the explanatory variables are associated to an increase in the proportion of daily travel time by PV (Table 6). Almost all individual coefficient estimates are highly significant (95% confidence level or more). In general, signs of the estimated parameters are consistent with expectation and previous studies.

Results show that those who participated in the TBCP are more likely to reduce their proportion of daily travel time by PV, specifically in a 5.3%. In other words, those who participated in the TBCP are more likely to spend more time travelling by other modes like public transportation, cycling or walking. This is an important finding: the TBCP had a significant effect on reducing car use of regular drivers who were not especially willing to do so.

Respondents over 50 are also more likely to reduce their proportion of daily travel time by PV in comparison to middle aged or young respondents. Reasons that would explain this result are: being able to arrive anywhere without a car, health reasons, heavy traffic and retirement.

On the other hand, women appear to be more likely to be persuaded by the TBCP and reduce their proportion of daily travel time by PV. This may be related to the fact that they have unequal access to PV and they often travel by public transportation or on foot. In contrast, Meloni *et al.* (2013) found that males were more likely to choose public transportation instead of car when they receive information related to a tram

alternative. Thus, it is difficult to draw any conclusion because the relationship between gender and mobility is always influenced by other variables.

Divorced people tend to increase their proportion of daily travel time by PV in comparison with married and single people or those who share household. To be divorced or separated affects the structure of the family and so does their mobility behaviour, especially where joint custody exists.

Respondents who have studied a master's degree are more likely to be persuaded by the TBCP and reduce their proportion of daily travel time by PV. Nenseth *et al.* (2012) also found a positive relationship between education level and low car use. They related education to urbanization, in terms of societal, economic and cultural factors, being important for more sustainable mobility patterns.

On the other hand, living with family during weekdays is also related to reducing the proportion of daily travel time by PV. Therefore, they are more likely to use other modes like walking, cycling or public transportation. The explanation could be that car availability reduces among the members of the family, which causes a higher use of alternative transportation modes.

Finally, workers are less likely to be persuaded by the TBCP in comparison to students, unemployed or the retired. This may be related to low spatial and temporal flexibility of jobs.

The number and availability of cars are also significant variables in terms of increasing time allocated to day travelling by PV. Logically, the more cars at home and the more availability are related with more freedom and more likelihood to use them instead of alternative modes.

Finally, as expected, the willingness to reduce car use is associated to reduce their proportion of daily travel time by PV.

Similarly, the more daily trips the higher probability of reducing the proportion of daily travel time by PV. Habitual drivers use very frequently their PV for commuting. When they carry out additional trips to perform other activities like shopping, entertainment or social relationships, there is a higher probability of using alternative modes if these activities are located near home.

The parameter reported as sigma is the estimated standard error of the regression. The high significance of the sigma parameter suggests that for the data truncation, the lower limit level of zero cannot be ignored and the estimation method must deal with the asymptotic distribution of the data.

According to the estimated partial effects, the highest impact on the likelihood to increase the proportion of time allocated to travel by PV corresponds to divorcees, who increase the proportion in 18.7%. Car availability is related to an increase in 11.9%. On the other hand, to be older than 50 is related to a reduction of the proportion of time allocated to travel by PV in 7.2%. To be willing to reduce car use is related to a reduction of the proportion of time allocated to travel by PV in 6.6%.

Table 6. Model 1 Results

All participants			
RATIO	**Coefficient**	**Std. Error**	**Prob |z|>Z***
Primary Index Equation for Model			
Constant	0.70871	0.11771	0.0000
TBCP	-0.13053	0.04347	0.0027
SENIOR	-0.17801	0.06975	0.0107
GENDER	-0.10327	0.04370	0.0181
DIVORCED	0.45970	0.11362	0.0001
MASTER	-0.09174	0.04656	0.0488
FAMWEEKDAY	-0.14363	0.06488	0.0269
WORKING	0.16431	0.04872	0.0007
CAR	0.16482	0.02891	0.0000
CARAVA	0.29128	0.05003	0.0000
WILLING	-0.16072	0.05410	0.0030
TOTALTRIPS	-0.04594	0.01018	0.0000
Disturbance standard deviation			

Sigma	0.59412	0.02189	0.0000

RATIO	**Partial effect**	**Std. Error**	**Prob |z|>Z***
TBCP	-0.05315	0.01764	0.0026
SENIOR	-0.07249	0.02835	0.0106
GENDER	-0.04205	0.01777	0.0180
DIVORCED	0.18719	0.04588	0.0000
MASTER	-0.03736	0.01895	0.0486
FAMWEEKDAY	-0.05849	0.02643	0.0269
WORKING	0.06690	0.01979	0.0007
CAR	0.06711	0.01172	0.0000
CARAVA	0.11861	0.02033	0.0000
WILLING	-0.06545	0.02195	0.0029
TOTALTRIPS	-0.01871	0.00407	0.0000
Number of observations			1069
Log likelihood function			-770.60579

Considering that the participation in the TBCP is one of the significant variables influencing the reduction of the proportion of daily travel time by PV, we decided to analyze this influence in more detail. Using as a starting point the hypothesis that participating in the TBCP does not affect everyone in the same way, we analyzed data from participants and non-participants in the TBCP separately. Models 2 and 3 in Table 7 present the results of these second analyses. These models let us know who should be a better target for TBCP.

There are some variables which are significant in the model with data from participants in the TBCP but are not significant in the model with data from non-participants. In those cases, we can confirm their effect of participating in the TBCP. Thus, for those respondents who are married, participating in the TBCP had a significant effect in their likelihood to reduce their proportion of daily travel time by car or motorbike. Similarly, participating in the TBCP had an important influence on the probability of reducing car and motorbike use to those unemployed participants. Both groups of people could be related to those with a greater need of optimizing their

economic resources. This may explain a greater acceptance and implementation of the information given in the TBCP, considering that savings is one of the main direct consequences of reducing PV use.

Finally, participating in the TBCP also had a significant effect on those who are willing to reduce their car use. This means that willingness to reduce car use is an important first step but in many cases is not enough to obtain results. External support is often needed to change mobility behaviour.

According to the estimated partial effects, the willingness to reduce car use presents the highest impact on the likelihood to decrease the proportion of daily travel time by PV (-13.7%), followed by being unemployed (-8.8%)

Table 7. Models 2 and 3 Results

	TBCP participants			CG participants		
RATIO	**Coefficient**	**Std. Error**	**Prob |z|>Z***	**Coefficient**	**Std. Error**	**Prob |z|>Z***
	Primary Index Equation for Model					
Constant	0.64039	0.16209	0.0001	0.43432	0.14708	0.0031
MARRIED	-0.15659	0.06253	0.0123	0.09388	0.06488	0.1479
DIVORCED	0.51150	0.17274	0.0031	0.45920	0.15967	0.0040
UNEMPLOYED	-0.19264	0.10975	0.0792	0.03889	0.10513	0.7114
CAR	0.10696	0.03278	0.0011	0.09696	0.04387	0.0271
CARAVA	0.32255	0.07632	0.0000	0.35405	0.06566	0.0000
WILLING	-0.29914	0.08128	0.0002	-0.10301	0.07470	0.1679
TOTALTRIPS	-0.10222	0.02203	0.0000	-0.09669	0.01993	0.0000
TOTALTIME	0.22424	0.06229	0.0003	0.22198	0.05996	0.0002
	Disturbance standard deviation					
Sigma	0.54683	0.02834	0.0000	0.63094	0.03296	0.0000

RATIO	**Partial effect**	**Std. Error**	**Prob |z|>Z***	**Partial effect**	**Std. Error**	**Prob |z|>Z***
MARRIED	-0.07184	0.02862	0.0121	0.03451	0.02378	0.1467
DIVORCED	0.23466	0.07855	0.0028	0.16879	0.05815	0.0037
UNEMPLOYED	-0.08838	0.05024	0.0785	0.01430	0.03864	0.7114
CAR	0.04907	0.01499	0.0011	0.03564	0.01612	0.0270
CARAVA	0.14798	0.03492	0.0000	0.13014	0.02399	0.0000
WILLING	-0.13724	0.03697	0.0002	-0.03786	0.02739	0.1669
TOTALTRIPS	-0.04690	0.00984	0.0000	-0.03554	0.00715	0.0000

TOTALTIME	0.10288	0.02830	0.0003	0.08159	0.02202	0.0002
Number of observations			470			599
Log likelihood function			-337.25914			-425.44142

3. Conclusions and discussion

This paper aims to assess the effect of participation in Travel Behaviour Change Programs (TBCP) on the observed daily use of private vehicle (PV). For this purpose, data from the second wave of a two-wave activity scheduling process panel survey conducted in the city of Valencia (Spain) was used. Approximately 62 per cent of the panellists participated in the TBCP between both survey waves, and the rest were panellists who did not participate in the TBCP and were included in a Control Group. In this analysis, Control Group also included second wave new recruits, who had not participated in the TBCP either. TBCP were composed of three different actions defined to cope with respondent's psychological internal barriers to modify travel behaviour. Persuasion principles of reciprocity, scarcity, authority, social proof and liking were used to define the actions.

The proportion of daily time allocated to driving has been analyzed using doubled censored Tobit models. We have found that participating in the TBCP significantly reduce daily time allocation to private vehicle usage. This is the direct indication of the effectiveness of TBCP in reducing over-reliance on private vehicle in our daily life. This finding proves that TBCP can be a complementary policy initiative to other capital intensive policies, e.g. infrastructure developments. Moreover, our empirical investigation also reveals that personal attributes, e.g. age, gender, education, etc. play a role in defining variations of the use of private vehicle. Further analysis carried out comparing data collected from participants and non-participants resulted in that the TBCP does not affect everyone in a similar way. It becomes clear that personal

attribute, e.g. marital and employment status are the key defining factors. However, willingness to reduce car use is found to be the decisive factor in making maximum benefit of TBCP effects.

The results of this investigation demonstrate that participating in the TBCP had a direct impact on reducing car and motorbike use. This study has been developed with usual drivers and results show that those who participated in the TBCP are more likely to reduce their proportion of daily time allocated to travelling by private vehicle (PV), specifically in a 5.3%. This study uses an unbiased approach by identifying habitual drivers who in general were not willing to reduce their private car use before they entered into the experiment. Such neutral approach makes the findings of this investigation generic in the sense that these findings can be extended to a general population. For instance, in Valencia the average proportion of daily time allocated to travelling by PV is 0.331 which means 604,500 daily trips in PV (SUMP Valencia 2013). If we expand those results to the total population of drivers in Valencia, and we assume that people who are not usual drivers would reduce their proportion of daily time allocated to travelling by PV at least the same as those people who use their PV for almost all their trips, a daily reduction of almost 31,150 PV trips could be achieved. Considering an average trip length of 4.8 km and an average CO_2 emission of 180gr/km, we could say that TBCP application in Valencia would avoid 26,914 kg CO_2 emission each day.

However, the survey methodology used resulted in a sample where people older than 60 were poorly represented. Another limitation is that, considering the definition of the two-wave panel survey, we were able to assess the medium-term effects of the TBCP. Therefore, our study could be improved by considering carrying out a third wave in order to evaluate the longevity of the effects in the long-term. In terms of modelling

approach, our study could also be improved by considering some variables as continuous variables instead of dichotomous variables. Finally, other improvements to our methodology could be having a larger sample or contacting a disinterested third party to conduct the evaluation.

Considering the results obtained in this research, Travel Behaviour Change Programs can be more effective by taking into account further individual and family attributes. Besides, analyzing the effects caused by each persuasion action on their own would also help to acquire a deeper knowledge on their potential. Results of this investigation reveal that soft transportation policies, e.g. TBCP, can significantly reduce car use and its negative externalities. Compared to any other policies that have economic consequences (e.g. pricing for parking, congestion pricing, fuel tax, etc.), TBCP would have long lasting effects in terms of sustained reduction of private automobile usage. The main reason is that the effects of TBCP are derived by self-motivation and self-learning by the people. Compared to enforceable policies, TBCP would clearly have edge in considerable achievement of carbon emission mitigation plans. TBCP plays the role of social marketing, but with informed education to individual participants than wide range and random information dissemination. However, obtaining maximum benefit of TBCP may take longer time than other enforceable and/or economic policies. So, the policy recommendation of this study is to develop comprehensive policy initiatives, where TBCP would be a core part of the policy structure along with infrastructure investment and/or economic policies.

Similar analysis will be carried out using data from the two waves of the activity scheduling process panel survey. The effect of participating in the TBCP on scheduling and rescheduling activity-travel episodes can be studied introducing important variables as location of the activities/destination of the trips. Future research will also analyze if

the effect of participation in the TBCP affects in a different way the travel behaviour during the weekends.

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