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Carpooling and carpool clubs: Clarifying concepts and assessing value enhancement possibilities through a Stated Preference web survey in Lisbon, Portugal

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ABSTRACT

The increase of urban traffic congestion calls for studying alternative measures for mobility management, and one of these measures is carpooling. In theory, these systems could lead to great reductions in the use of private vehicles; however, in practice they have obtained limited success for two main reasons: the psychological barriers associated with riding with strangers and poor schedule flexibility. To overcome some of the limitations of the traditional schemes, we proposed studying a carpooling club model with two main new features: establishing a base trust level for carpoolers to find compatible matches for traditional groups and at the same time allowing to search for a ride in an alternative group when the pool member has a trip schedule different from the usual one. A web-based survey was developed for the Lisbon Metropolitan Region (Portugal), including a Stated Preference experiment, to test the concept and confirm previous knowledge on these systems' determinants. It was found through a binary logit Discrete Choice Model calibration that carpooling is still attached with lower income strata and that saving money is still an important reason for participating in it. The club itself does not show promise introducing more flexibility in these systems; however, it should provide a way for persons to interact and trust each other at least to the level of working colleagues.

1. Introduction

The continuous rising of car use deriving from urban sprawl and car ownership growth is still making traffic congestion more frequent in urban areas (Bukold et al., 1996; Schrank and Lomax, 2005). The majority of trips are single occupant vehicle trips (SOV) resulting in more cars for the same number of persons. In 1990, approximately 90% of the work trips and 58% of the other trips in United States were done in SOV (Shaheen et al., 1999). Numbers of 1997 show that the average occupancy rate of the automobiles in commuting trips for the 15 countries of the European Union was, at that time, in the interval between 1.1 and 1.2 persons per vehicle (IEA, 1997). Hence the problem is not so much car ownership increase but mainly the way the automobile is used, and when it is used, "A good deal of the demand for transport is concentrated on a few hours of the day, in particular in urban areas where most of the congestion takes place during specific peak periods" (Ortúzar and Willumsen, 2001), generally the morning and evening commuting periods.

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Carpooling is considered an interesting Transport Demand Management (TDM) tool that has produced some diminishment in the number of SOV trips in the past, mainly when applied to employment centers where persons have their companies in common (Wartick, 1980; Willson and Shoup, 1990; Bianco, 2000). The other alternative is household carpooling, yet this has proven to be very inefficient in decreasing work related auto trips (Bard, 1997; Morency, 2007). An increase in scale of participation, from companies to large-scale systems, has always been the objective of public policy making. Still, early research has shown that this is difficult to achieve due to the high probability of sharing the vehicle with a non-acquaintance (Duecker et al., 1977).

On the other hand, the classical carpooling systems have low flexibility, particularly in handling schedule variations and destinations that persons sooner or later will have, which is aggravated by the dependence on other persons that carpooling entails (Stephen and Duecker, 1974; Margolin et al., 1978; Concas and Winters, 2007). This has resulted in only a small percentage of the persons who make a positive change in commute-mode to carpooling to stay with this new mode until they are not traveling to their workplace anymore (Smith and Beroldo, 2002).

The question that arises out of the previous research is if there is any way to improve carpooling attractiveness and resilience by considering a different form of organizing and promoting this transport alternative. Most of the research projects on this subject were published in the seventies and eighties; thus, there is the need for further exploration of the sources for its lack of success in reaching ways to improve carpooling usage.

We were moved by the will for proposing a new model for a carpooling systems' organization which could overcome the limited results from past applications. We took advantage of the relative inexperience with carpooling systems in the Lisbon Metropolitan Area (LMA) in Portugal with three million inhabitants (the largest in the country) to evaluate the main motivations and deterrents to carpooling. In this, we tried to assess which demographic characteristics and commuter situations would be more favorable to the acceptance of carpooling.

We started by reviewing the state-of-the-art and state-of-the-practice of carpooling systems in order to derive the attributes of a carpooling club which could, in theory, overcome previous limitations of this transport alternative. To test this structure, a web-survey was set up on the internet comprised of two sections: the first, for collecting socio-demographic and usual commuter trip data and the second, with a Stated Preference (SP) experiment presenting four binary choices for each respondent comparing his current driving situation and an alternative with external (non-household) carpooling.

The paper is organized in the following way: in the next section, the carpooling structure in the form of clubs is derived from past experience and research. Then, a review of the main factors found to influence carpooling in the past is presented in order to support the survey design. This is followed by the construction of the SP web survey that was made available on the web for the Lisbon region. Next, the Discrete Choice Model (DCM) estimated with the SP data is presented. The article continues with a detailed analysis of the main results and finishes with a discussion and conclusion on its main findings.

2. Deriving a carpooling structure in the form of clubs

After reviewing the previous studies, two main problems came out to be the most limiting factors for carpooling: the psychological barrier of riding with strangers, which is necessary for expanding the scale of the systems; and poor schedule flexibility, where near term schedule changes are very difficult to be managed by traditional systems.

In order to cope with these two main problems, we researched a structure for managing carpooling in the form of clubs, which aims working upon schedule flexibility and psychological issues in different perspectives with the purpose of bringing more participants to this transport option.

For managing schedule variations, the club can be set to manage both traditional stable groups and a dynamic ridematching service in the same structure taking advantage of their compatibility. Traditional stable pool groups would be the core of the system, and when space is available in a group, it can be allocated dynamically to an occasional demand from a person who normally belongs to another pool in the club (Correia and Viegas, 2009).

Dynamic ridematching services or instant ridesharing have been tested before, mainly in the United States, but they have proved to be very ineffective when applied independently (Giuliano et al., 1995; Haselkorn et al., 1995; Dailey et al., 1999). From the physical dimension perspective, the technology that is needed to implement these systems exists and is ready to be deployed (Hartwig, 2007). Its success, however, strongly depends on the willingness to share a ride with a possible stranger, and this has proven critical for the development of the concept.

The club structure that is proposed and was tested is based on users who can act both as passengers and drivers. This is actually placing a constraint, which has been recognized to influence carpooling propensity, but our goal was to design a club aiming at higher occupancy rates, improving commuter trip sustainability. So, the main target was to reduce the number of SOVs by bringing those solo drivers into the club, and it was assumed that all these club members could act both as drivers and as passengers.

From a psychological standpoint, the club structure aims to provide a common minimum level of trust between its members by filtering and accompanying all the groups. We want to test if this can provide sufficient confidence in order to make it easier to accept persons who are not acquaintances.

Previous research has focused on these issues and their impact on carpooling performance. Early on, Kurth and Hood (1977), found that appeals to self-interest made through work organizations were more effective than other means of encouraging carpooling not only because the poolers have similar work schedules, but also because the work organization

establishes a base trust level between participants. More recent studies also led to the same conclusion: persons are likely to trust others who share their organizational affiliations and are more likely to engage in interactions, exploiting group identity to form personal bonds (Prentice et al., 1994; Mcknight et al., 1998).

This suggests the importance of a common basis for establishing a relationship of the kind needed to form carpooling groups. "Creating a group whose members have similar interests will tend to make the group more attractive, and emphasizing to group members their unique skills or knowledge will tend to make them believe their efforts matter"(Terveen and McDonald, 2005). The amount of exposure persons have to each other strongly influences the likelihood of interpersonal interaction. Persons who are physically close are likely to meet and interact frequently allowing friendships to develop.

3. Factors that affect carpooling propensity and resilience

There are many factors which have been found to influence carpooling acceptance and these should be included for evaluating the club's attractiveness. In general one may divide these factors into four main classes: Transport System characteristics, Carpooling Group characteristics, Individual/Household characteristics, and Conditions at the Workplace (Hunt and McMillan, 1997).

Transport system characteristics, especially those connected to cost and time attributes, are the primary instrument factors behind mode choice and have usually been disaggregated in several parts in order to study their impact on carpooling. For travel time, researchers have been differentiating in-vehicle time and extra in-vehicle time due to carpool arrangements (Bruggeman et al., 1977; Kostyniuk, 1982; Giuliano et al., 1990; Brownstone and Golob, 1992; Hunt and McMillan, 1997) this distinction was introduced for measuring the inconvenience of picking up carpool partners and is needed to assess the added value of policies directed at decreasing travel time for carpoolers through HOV or HOT lanes (Dahlgren, 2002; Menendez and Daganzo, 2007; Kwon and Varaiya, 2008). Walking is also particularly important in carpooling, since it is often part of an itinerary when persons have to meet others in intermediate locations for participating in pool groups (Gensch, 1981; Hunt and McMillan, 1997).

Travel costs have been separated in-vehicle operation costs (Bruggeman et al., 1977; Teal, 1987); those mostly connected with fuel costs; toll costs; and workplace parking costs (Bruggeman et al., 1977; Hunt and McMillan, 1997). This separation has allowed for the analysis of the impact which different incentives can have on carpooling propensity, namely parking-price reduction or toll-cost reduction for carpoolers.

Although these items are important to differentiate all modes of transportation, carpooling has attributes which are inherent just to this option. The availability of potential carpooling partners and their relationships has proved to be of paramount importance (Kurth and Hood, 1977; Kostyniuk, 1982; Levin, 1982). Groups can be organized in different ways; this could also help determine the system attractiveness, such as the number of days to carpool (Glazer et al., 1986), denoting more or less constrained arrangements and the driving decision (who drives) (Kostyniuk, 1982; Levin, 1982; Hunt and McMillan, 1997).

Another stream of research explored the influence of socio-demographic characteristics of both the potential carpooler and his household. Household-size and composition together with car-availability and total income were explored and found to influence carpooling choice (Kurth and Hood, 1977; Teal, 1987; Brownstone and Golob, 1992). Individual characteristics, such as age and gender, have also been looked at and found relevant (Gensch, 1981; Teal, 1987; Brownstone and Golob, 1992). Also, at an individual level, the currently used mode and constraints on schedule and mobility that carpooling usually entails also prove to be very important (Bruggeman et al., 1977; Gensch, 1981; Kostyniuk, 1982; Giuliano et al., 1995).

Conditions at workplace may also play an important role. Factors such needing the car for work, parking availability and the availability of a company guaranteed-ride-home were also researched and have proved to influence carpooling choice. Parking supply stands out as one of the most researched aspects which has lead, generally, to the conclusion that when parking is easy, carpooling decreases its attractiveness. (Ben-Akiva and Atherton, 1977; Kostyniuk, 1982; Brownstone and Golob, 1992).

4. Web survey for the Lisbon Metropolitan Area

4.1. Setting up the web survey

In order to evaluate the potential of the club structure for managing carpooling groups in a metropolitan area, a web survey was advertised and made available during four months, from February to May 2008, in the Lisbon Metropolitan Area (LMA) in Portugal.

Several kinds of surveys have been applied in the past focusing on different aspects of these systems. Their complexity varied from focus groups (Stephen and Duecker, 1974) to Stated Preference (SP) surveys with the objective of estimating DCMs (Hunt and McMillan, 1997). The goals have been varying from knowing the preferences of carpooling systems organization to forecasting the mode share that these schemes could achieve through their instrumental attributes, as well as the characteristics of the decision-makers and their mobility situation.

As we have seen through the publication dates of the papers cited in the previous section, the majority was developed in the seventies and eighties after the oil crisis of 1973. So, in addition to assessing the added value of the club scheme towards attractiveness of carpooling, the changes in the framework conditions were enough to justify revisiting the topic. Previous results should be compared on the strength of each aspect affecting carpooling potential for the current time period and for the specific case of the LMA.

The survey was organized in two main parts:

- *Socio-demographic and usual commuter trip information* – This part of the survey was mainly intended to collect information on the household and individual socio-demographics, current mobility patterns and workplace parking supply.
- *Stated Preference* – In this part of the survey, an SP experiment was presented to commuter drivers in the LMA comparing external carpooling (non-household participants) and the driving alone or with family alternative. Four choices were generated to adapt as much as possible to the respondents' stated mobility situation. The two first choices compared the alternative "Alone/With family" and "Carpooling" and the other two comparing the "Alone/With family" option with the "Carpooling Club" option. By answering diverse SP choices, the respondent supplied information for calibrating a binary logit DCM.

The classical approach to build SP experiments establishes attribute levels for the explanatory variables and then takes these levels to build a design which is presented to the respondents. The full-factorial design, which would result from all possible combinations of these levels, normally results in too many choices. The alternative is to use a fractional-factorial design with the attribute levels, searching for a combination of the parameters that result in null correlations among the attributes. This procedure is currently available in several statistical packages.

Independence among the attributes allows evaluating the main effects of one variable on choice independent of the effects that the other variables may have. However, by generating these choice sets, some alternatives which are generated may not be plausible and may affect the respondent trust in the survey, and at the same time, be conducive to a problem of identification of the interviewee with the situations that are described. The option is creating designs that are built pivoted around the experiences of sampled respondents (Hensher, 2004) "The use of a respondent's experience, embodied in a reference alternative to derive the attribute levels of the experiment, has come about in recognition of a number of supporting theories in behavioral and cognitive psychology and economics, such as prospect theory, case-based decision theory and minimum-regret theory" (Rose et al., 2008).

Nevertheless, the use of reference alternatives does not fit the methods of efficient generation of SP choice sets. "When the attribute levels are pivoted as percentages around some base reference alternative consisting of the attribute levels reported by the individual respondents during the survey task, the precise (absolute) attribute levels will not be known to the analyst prior to conducting the survey" (Rose et al., 2008). Thus, it is impossible for the researcher to know the efficiency level of the design prior from going to the field, introducing a great uncertainty on the correlations outcome.

In the survey reported here, we wanted to create situations for the "Alone/With family" alternative, which resembled as much as possible, the current behavior of the respondent and at the same time, creating a carpooling option with seamless attributes given the usual impact that this mode can have on a commuter trip, particularly on time and cost variables.

These relations between current driving costs and time, and the new variables for carpooling, suggested using some sort of rules for generating the new values. This method, however, despite being expected to elicit more realistic behavior, it may result in correlations within the data structure, which can make the estimation of the model parameters more problematic, so a balance between degree of dependency and data structure had to be established. This is a problem to which we gave specific attention, by subsequently evaluating the correlations that resulted among the attributes.

Two attributes were used for generating the carpool external occupants: their number and type. However, given that the objective was to adapt as much as possible to the current transport arrangements of the respondent, we had to check whether the respondent was already transporting a household passenger to work before external passengers could be generated (information extracted from the first part of the survey). A household passenger (PAX_HOUSEHOLD) was only considered when the respondent stated that he departed with other persons from home and stopped to drop someone off at a workplace. In those situations, the transport of one household person was considered both in the situation with and without carpooling, assuming that this person would also be part of the group, alternating just like the others.

Another important type of household member was also considered. Transport of children to school is usually a constraint to participate in carpooling schemes; thus, when the respondent stated he had to do it some days of the week, this was introduced both in the option without carpooling and with carpooling, assuming that the carpooling group would have a detour to make this drop-off (CHILDREN_STOP).

Having generated the existence of household passengers to work or school, we were able to randomly generate the number of other occupants considering a maximum vehicle occupation of four persons. These other-occupants type varied in the categories of "friend," "colleague," and "carpooling club member," this latter option only appearing in one of the two choices with a carpooling club. We opted not to include other characterizing elements, such as gender or age, given that it would not be possible to include all these characteristics in a SP experiment.

The number of days to carpool was randomly generated between two and five days in a working week (N_DAYS_WEEK). This number of days was presented as an attribute of the carpooling system and was intended to measure the difference in

convenience that a carpooling scheme can have depending on the number of days that its participants have to compromise to a shared schedule.

The experiment was focused on the morning commute when referring to travel time. In the system we tested, carpool members are supposed to alternate between being the driver and being a passenger. When the carpooling alternative was presented, the driving time (home to work) for the situation where the respondent is acting as driver was shown, as was the walking time from his home to a meeting point when he is a passenger and walking time from a parking place to his workplace when he is a passenger (Fig. 1).

The driving time was randomly generated in a range close to the difference between the arrival at the workplace and the departure from home stated by the respondent in the first part of the survey (DRIVING_TIME). Then a random period of time was added for each partner he had to pick-up according to a number of extra-passengers (DRIVING_TIME_CARPOOL). The sum of these periods is the extra in-vehicle time he has to spend to pick-up the remaining partners in relation to what he usually spends. This approach made it easier for the respondent to evaluate how much more time he is spending in-vehicle when it is his turn to drive (EXTRA_DRIVING).

The time to walk to a meeting point in the morning when the person is a passenger was randomly generated in the interval between 0 and 15 min (MEETING_POINT_TIME). The null value represents the situation where the passenger is picked-up at home. The walking time from the parking lot to the workplace in the city center was randomly generated in the interval stated by the respondent in the first part of the survey (PARKING_WALK_TIME); the null value represents the situation where the passenger is dropped-off at his workplace. In the situation with carpooling, a random period in minutes was added to that time to consider the fact that when the respondent is acting as a passenger, he may have to walk from a parking place near the workplace of the driver to his own workplace, taking longer than usual (PARKING_WALK_TIME_CARPOOL). The survey did not address the return trip, implicitly assuming it would be symmetrical to the morning commute.

Expenses were presented in different scales, trying to give numbers to the respondent with which he could easily identify. Current travel costs have been presented separating fuel costs (weekly expense), parking and toll costs (daily expenses) and were based on the responses given in the first part of the survey, taking those intervals and generating a random value in them (PARKING_EXPENSES, TOLL_EXPENSES and FUEL_EXPENSES). When the respondent stated having no expenses with tolls or parking this situation was replicated in the SP experiment. The costs in the carpooling situation were computed using an equation that considered the savings that the respondent benefits from carpooling with x persons (only external to the household and including the driver) in y days in a proportional way:

$$\%\text{Expenses reduction} = 1 - \left(\frac{y}{x \times 5} + \frac{5-y}{5}\right).$$

Two other variables have been used to introduce variations in the savings resulting from participating in carpooling schemes: a special parking price for carpoolers and a reduced price in tolls for carpoolers. Variations on these issues of parking and tolls were discussed but not retained for reasons of duration of the survey (avoidance of respondent fatigue) and of parameter calibration. A special parking price does not require investment in allocating specific parking places in the city center and a HOT pricing system (lower price for higher occupancy) does not demand the creation of a HOV/HOT lane. Moreover, the HOT pricing measure has been pointed as a strategy for the future in Lisbon (Diário da República, 2008), particularly in the heavy traffic bridges that give access to the city center.

Finally, another two variables were added respecting to the carpooling clubs option: the availability of a guaranteed-ride-home program organized by the club (RIDE_HOME) and the possibility of riding in other groups of the club when having a different destination or the same destination with another schedule (FLEXIBILITY).

4.2. Presenting the alternatives

The introductory text for the carpooling club choices was the following: "Now we introduce the broader concept of a carpooling club, which encompasses the management of several groups with the objective of benefiting from its scale.

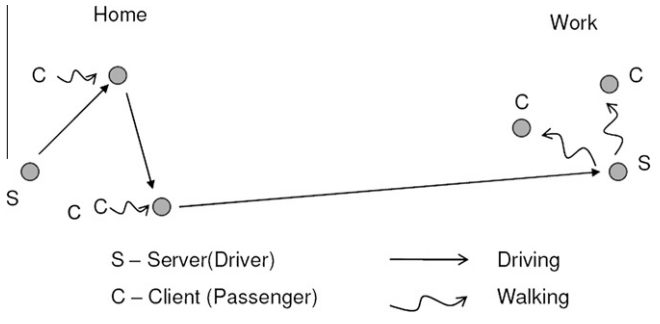

Fig. 1. Scheme for the pick-up and drop-off of passengers.

Due to the involvement of persons who do not know each other, participating in this club demands the achievement of a number of rules which allow assessing the suitability of persons to participate in this system, namely a valid driver's license, updated auto insurance, and possibly other examples of proof of safe driving.

In this club, you can find a compatible group for your daily commute through a search in the database of other subscribers in your place of residence. The group functions in the usual way, which is to say that you alternate between driver and passenger. At the same time, groups will be monitored by the club, assuring that everything is going well and warning its participants if someone has misbehaved. In the limit, if it is a serious situation, those participants might be expelled from the club. Thus the club serves as a moderator which should provide more trust for those who decide to use this system". Table 1 presents the SP choices web-presentation with its corresponding variables.

The options were labeled in order to allow calibrating an alternative specific constant (ASC) for one of the alternatives. The attributes were presented side-by-side, allowing an easier comparison among both alternatives. The two first carpooling attributes were only shown for the two carpooling club choices.

5. Discrete Choice Model calibration

There were a total of 996 respondents that answered 3984 SP comparisons with an almost perfect balance between the "Alone/With family" answers and the "Carpooling" answers, 53% and 47% of the choices, respectively. This is very encouraging for carpooling; however, we should recognize that this result strongly depends on the (self-selected) sample, as well as on the effects of answering a Stated Preference survey, very often influenced by sentiments of wanting to be "politically correct". It is also noteworthy that as much as 60% of the answers were given by respondents who preferred either "Alone/With family" or "Carpooling" in all of the four stated choices, which is possibly an indicator of strong opinions on the subject.

The correlations between all variables were computed using the full database of SP answers, where we found that most of the values were not very high. The greatest correlations occurred between the values of expenses and time variables, not surpassing 0.6 for the situation with and without carpooling, which is aligned with our concerns for plausibility and was expected given the construction process.

The NLOGIT® Version 4.0 module of the program LIMDEP® was used to estimate several DCM for the obtained SP data. This software package allows for specifying the utility functions, using a maximum likelihood estimation of a DCM, and performing several statistical tests on the results.

Table 1
Stated Preference web presentation.

Alternative A (without carpooling)	Alternative B (with carpooling)
	Carpooling Club Attributes (only for the two last choices): FLEXIBILITY RIDE_HOME
Occupants: YOU PAX_HOUSEHOLD	Occupants: YOU PAX_HOUSEHOLD PASSENGER_TYPE [Colleague, Friend or Carpooling Club Partner]
Transport of children: CHILDREN_STOP	Transport of children: CHILDREN_STOP Number of days a carpooling days: N_DAYS_WEEK
Time driving: DRIVING_TIME	Total time driving when you have to drive and pick-up the other partners: DRIVING_TIME_CARPOOL (extra driving time: EXTRA_DRIVING) Time to walk to the meeting point when you are a passenger: MEETING_POINT_TIME
Time to walk from parking lot to the workplace: PARKING_WALK_TIME	Time to walk from the parking lot or drop-off point to the workplace when you are acting as a passenger: PARKING_WALK_TIME_CARPOOL
Daily expenses with parking: PARKING_EXPENSES	Daily expenses with parking: PARKING_EXPENSES_CARPOOL (special parking: SPECIAL_PARKING)
Daily expenses with tolls: TOLL_EXPENSES	Daily expenses with tolls: TOLL_EXPENSES_CARPOOL (Reduced toll: HOT)
Weekly expenses with fuel: FUEL_EXPENSES	Weekly expenses with fuel: FUEL_EXPENSES_CARPOOL
Summary of the monthly expenses with parking, toll and fuel: TOTAL_COST	Summary of the monthly expenses with parking, toll and fuel: TOTAL_COST_CARPOOL

In this article, the end results of applying several specifications of a binary logit DCM to the data are presented, while avoiding going through all the steps and iterations which were needed to reach a final exploratory specification. It started to be specified only with the attributes of the alternatives, and then, all possible information from socio-demographic and commuter trip characteristics were gradually added, taking advantage of the survey's first stage for direct choice explanation purposes.

Cost and time attributes were included in both utility functions' specification since these vary between alternatives. All the other variables were specified in the carpooling utility function, thus turning the "Alone/With family" option as the reference alternative for the model. An ASC was also included in the carpooling utility specification for capturing the average effect on utility of all factors which are not included in the model. Table 2 presents the final specification of variables in terms of their best significance, overall goodness of fit, and importance for carpooling understanding.

For better understanding of the model specification, we should add the following notes: Differentiating the coefficients of travel time components proved to increase model goodness-of-fit, whereas for costs, there was no statistical significant variation among its components. The logarithm was used both for the DRIVING_TIME and TOTAL_COST variables because it improved model explanatory power, meaning, for instance, that the same difference in total cost has a different impact on utility depending on the absolute value of the attribute. Another interesting model result was that it proved better to specify a coefficient for each carpooling club participant (ADCL1, ADCL2 and ADCL3), thus allowing better identification of the impact of this type of occupant in carpooling choice.

The final model calibration statistics were: Number of observations = 3984, Number of parameters for estimation = 37, $L(C) = -2753.2678$, $L(*) = -2392.073$, $-2[L(C) - L(*)] = 722.38922$, $\rho^2 = 0.13119$ and $\bar{\rho}^2 = 0.12304$. The values of ρ^2 and $\bar{\rho}^2$

Table 2
Best combination of explanatory variables in the DCM.

Variable	Description	Coefficient	SE
Attributes of the alternatives			
CHILDREN_STOP	1 if respondent drops-off a child, 0 otherwise	−0.5886***	0.1297
LN(DRIVING_TIME)	Logarithm of the driving time	−1.1820***	0.2652
MEETING_POINT_TIME	Time to reach a meeting point, walking	−0.0158**	0.0084
PARKING_WALK_TIME	Time to walk from the parking lot toward work	−0.0731***	0.0141
LN(TOTAL_COST)	Logarithm of the Total Transport cost (Gas, Tolls and parking)	−2.3181***	0.2900
NFRIENDS	Number of friends in the group	−0.0937	0.0910
NCOLLEAGUES	Number of colleagues in the group	−0.4046***	0.0956
ADCL1	1 if there is an additional colleague in the group, 0 otherwise	−0.4283***	0.1494
ADCL2	1 if there are 2 additional colleagues in the group, 0 otherwise	−1.1552***	0.2178
ADCL3	1 if there are 3 additional colleagues in the group; 0 otherwise	−1.2127***	0.4098
NHOUSEHOLD	1 if there is a carpool member belonging to the respondent' household; 0 otherwise	−0.8220***	0.1236
DAYS2	1 if carpooling is arranged for 2 days a week; 0 otherwise	0.0977	0.0996
DAYS5	1 if carpooling is arranged for 5 days a week; 0 otherwise	−0.2932***	0.1158
RIDE_HOME	1 if there is a guaranteed ride home; 0 otherwise	0.2423***	0.1128
FLEXIBILITY	1 if there is the option of riding in another vehicle when there is a near term trip; 0 otherwise	−0.2937***	0.1383
HOT_PRICE	1 if there is a reduction on tolls based in the vehicle occupation; 0 otherwise	0.2025***	0.1027
Socio-demographic profile			
AGE	The age of the respondent	−0.0141***	0.003
MARITAL	1 if the respondent is married or in a marital union; 0 otherwise	0.1670**	0.0879
STUDENT	1 if the respondent is a student; 0 otherwise	0.2126*	0.1425
WHITE_COLAR	1 if the respondent has a white collar job; 0 otherwise	−0.1975***	0.0774
CHILDREN16	1 if there are children under 16 years old in the household; 0 otherwise	0.1801**	0.0998
EMPLOYED	Number of employed persons in the household; 0 otherwise	−0.1458***	0.0513
VEHICLE_LUXURY	If the respondent usually drives a luxury vehicle; 0 otherwise	−0.3389***	0.1574
LICENSE_VEHICLES	Number of licenses per vehicle in the household	0.2041***	0.0920
COSTDIF_INCOME	Difference between both the costs of driving alone and the cost of carpooling, dividing by the average income	2.8105***	0.9055
Commuter trip characteristics			
DIFI_PARK	1 if respondent stated having difficulty parking his vehicle; 0 otherwise	0.4445***	0.1461
HOME_7–8	1 if respondent leaves home between 7 and 8 o'clock; 0 otherwise	0.2278***	0.0853
HOME_9–10	1 if respondent leaves home between 9 and 10 o'clock; 0 otherwise	−0.1745**	0.0953
WORK_19–20	1 if respondent leaves his work place between 19 and 20 o'clock; 0 otherwise	0.1816***	0.0817
PROFILE1	Binary variables denoting different levels of constrain in the car use. From less constrained (Needs	−1.0432***	0.2323
PROFILE2	the car at work less than 3 days a week and one morning activity less than 3 days a week and one	−0.8958***	0.2814
PROFILE3	afternoon activity less than 3 days a week) to highly constrained (needs the car for work every day	−0.9445***	0.2511
PROFILE4	and has an extra activity in the morning and afternoon every day)	−1.1831***	0.2271
PROFILE5		−1.2102***	0.2897
PROFILE6		−1.2728***	0.6425
A_CARPOOL	ASC of the carpooling alternative	1.8515***	0.3352

* Significant at 10%.
** Significant at 5%.
*** Significant at 1%.

compare the likelihood of the model ($L(*)$) with the likelihood of a model constituted only by alternative-specific constants ($L(C)$).

The resulting corrected pseudo-R^2 ($\bar{\rho}^2$) is not very high (0.12304). Nevertheless, one should not ignore the significance of the explanatory variables and their importance in helping to understate carpooling and the impact that the club structure may have. In that perspective, interesting results were reached.

6. Results

One very important clue for the lack of explanation of the model is the coefficient of the ASC variable (A_CARPOOL), which is positive and very significant, pointing to the fact that the variables mainly explained why the "carpooling" option is not chosen, not being able to capture more of the reasons of participating in such schemes (which appear embedded in the positive constant).

In general, the most promising carpoolers according to the survey will be young persons (AGE variable with a negative and significant coefficient) who are studying, or, if they are working, do not have a liberal profession or manager position (WHITE_COLAR variable coefficient is negative and significant), with a salary level that does not allow them to ignore the difference that carpooling can have on their monthly budget (COSTDIF_INCOME variable with a positive and significant coefficient in carpooling utility). This result confirms previous research which pointed to younger persons as one of the groups most willing to carpool (Tischer and Dobson, 1979; Longo et al., 2008) associated to a lower income (Gensch, 1981; Teal, 1987).

Persons from households where the number of licensed drivers was greater than the number of available vehicles showed higher tendency for carpooling (LICENSE_VEHICLES variable). The same was concluded in previous research on the demographics of carpooling: car availability significantly influences the willingness to carpool (Ferguson, 1995; Longo et al., 2008). Results also show that persons who chose carpooling tend to drive a city car lowering the probability of driving a luxury one (VEHICLE_LUXURY has a negative coefficient).

Results also point out that if these persons are married, this is an incentive for carpooling (MARRITAL variable with a positive coefficient), but only when they are not already transporting their spouses to the workplace (NHOUSEHOLD with a negative coefficient) which was also concluded before (McCoomb and Steuart, 1981). However, unlike other studies (McCoomb and Steuart, 1981; Ferguson, 1995), gender does not seem to be a good explanatory variable for distinguishing those who are willing to carpool from those who would not. This discrepancy may come from a greater significance of other factors that may be associated more with one gender, namely poor schedule flexibility or not having the priority in using the household vehicle. However, we should note the fact that the randomly generated partners of the group were not specified in their gender in the SP experiment, which could be important to classify the groups in terms of their attractiveness both to male and female respondents.

Variable CHILDREN_STOP presents a very significant negative coefficient in the carpooling utility. This was expected since some of the opinions respondents left in the database were against this option, stating they "would not like and did not think it would be feasible to transport their children to school in the carpooling group."

The survey also shows that the persons with greater willingness to carpool tend to have a full working or studying day from 8 to 19 (HOME_7–8 and WORK_19–20 are variables with a positive significant coefficient) and have difficulty parking the car at the work or study place (DIFI_PARK is positive and significant). This parking incentive confirms extensive previous research on the subject which reached the same conclusion (Ben-Akiva and Atherton, 1977; Willson and Shoup, 1990; Shoup, 1997; Bianco, 2000).

In terms of the PROFILE variables, we see that all of them have negative and significant coefficients, meaning that the need to use the car for work or other kinds of activity during the day, associated with participating in extra activities early in the morning or at the end of the afternoon, is a deterrent to carpooling.

When participating in this carpooling scheme the most promising commuters should prefer to carpool fewer days a week rather than the five working days, as this will make their full week commuter schedule too rigid (comparison between variables DAYS2 and DAYS5), a result which confirms preceding research (Glazer et al., 1986). When paying for tolls, results show a tendency for respondents benefiting from a HOT pricing system that would discriminate positively those who transport more passengers.

For participating in carpooling groups, persons have to spend time either picking-up and/or dropping-off their partners. Nevertheless, this is always limited and can have different weights depending on the stage of the tour. The time to go from a parking facility to the workplace seems to penalize the carpooling utility more than the time to reach a meeting point near the home place (comparison between the coefficients of the MEETING_POINT_TIME and PARKING_WALK_TIME variables).

Having available a guaranteed-ride-home program is a benefit that brings added value (RIDE_HOME variable is positive and significant), confirming the same result reached by Hunt and McMillan (1997). In what concerns the possibility of transporting others in a dynamic ridesharing program we see that the corresponding variable in the DCM (FLEXIBILITY) has a negative significant coefficient; thus, we may conclude that even by using a common base trust level, as the club is meant to be, persons do not view this possibility as an advantage but still face it as something suspicious, which does not bring added value to carpooling (similar to what happens in other dynamic systems).

The carpooling club member is a type of participant who is not trusted (ADCL1, ADCL2 and ADCL3 have significant negative coefficients), confirming the psychological effect that transporting persons who are not familiar can have in potential carpoolers (Duecker et al., 1977). However, we also observe that the additional number of colleagues has a negative impact on the carpooling utility; in fact, the impact of one colleague in the pool group is equivalent to one carpooling partner (NCOLLEAGUES variable comparing with ADCL1).

7. Discussion and conclusions

This paper presented the results of applying a web-based survey in the Lisbon Metropolitan Area (Portugal) for studying carpooling systems. An innovative structure in the form of clubs was proposed and postulated to improve carpooling attractiveness. The survey allowed assessing the enhancement possibilities of this scheme compared with the traditional ones, and at the same time, going back to the beginning of the research on these systems to update what was known to be the key factors for their attractiveness.

The fact that the population of the Lisbon region has not experienced organized carpooling has two concurrent implications for the study: on one hand, by not having participated in such groups, persons cannot grasp how carpooling can really change their mobility routines both in a positive or negative way. On the other hand, this leads them not to be affected by past failed experiences, being very open minded for new ways of travel.

A strong symptom that these respondents may not have had the full notion of what carpooling usually entails, is the fact that the DCM has pointed towards a very significant unexplained preference for carpooling. This is showing a special interest (curiosity?) for this alternative, which is probably fostered by its innovative aspects and by sentiments of social responsibility toward environment sustainability.

Nevertheless, results show great coherence when compared with the average behavior identified in the literature. Carpooling is still viewed as a more realistic alternative for lower socio-economic classes or for those who, due to their age, do not have their own private vehicle or do not have the resources to use it during the week. The difficulty in parking the vehicle plays an important role in determining carpooling attractiveness, which, given the situation in the Lisbon city center, may turn the option of being a passenger some days of the week an attractive one.

On the negative side, carpooling appears to be a service with very low flexibility. This is evident in the significant negative effect on carpooling preference of variables denoting routines with extra activities in the morning and/or afternoon. The preference for less carpooling days in a week also reinforces this perspective, showing that this alternative cannot be used every day.

The process of increasing flexibility through carpooling with non-familiar persons requires a system that provides a strong trust basis amongst carpoolers, and this has lead to the proposal of a carpooling club structure. It is grounded in psychology and social behavior research which points to these interaction platforms as being capable of fostering friendship and trust relations that are key aspects for allowing more resilient groups to be formed. This perspective was tested in the web-based survey stressing out the difference between carpooling among friends or colleagues and carpooling organized through the club. In that view, the type of occupant is paramount, and surprisingly all types of partners external to the household have scored a negative impact. Nonetheless, using as a comparative term the coefficients in the DCM, the carpooling club member has no more negative impact than work colleagues will have on carpooling preference, confirming the club as an interesting structure to form groups of persons with a certain trust basis.

Despite these promising results, when respondents were placed in the position of accepting transporting club members for a near term trip, response was not favorable, and this appears to be connected with partner instability. It seems that measures aimed at improving carpooling flexibility are faced with the worsening of other important aspects of the system, such as trust issues. Evidence from this aspect is the respondents' reactions to transporting their children in carpooling groups. Safety and security are increasingly important in urban societies where the multiplicity of perils often lead to distrust. This is a reality, and it seems not to be compatible with exposing children to non-familiar persons.

In summary, carpooling, despite being a simple concept which could at a first look be a very effective measure for decreasing urban congestion, has not been able to produce significant results in other cities, and the outlook in the Lisbon region does not seem more promising. The carpooling club scheme was not perceived as providing more benefits of flexibility than the inconvenience of travelling with people outside the household. Nevertheless, it continues to appeal to certain social groups due to economics or their more open attitudes and for these, the club may represent an interesting platform for meeting other carpoolers.

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