Policies and Incentives toward Car-Sharing and Ride-Matching

A field study based on employees' preferences in Stockholm

Markus Robèrt
Department of Environment and Planning
The Royal Institute of Technology
100 44 Stockholm
markus@infra.kth.se

Abstract

In relation to traffic problems, climate change, and the transition to renewable energy systems which is of increasing concern globally, a growing number of companies support their employees to choose more efficient means of personal travel. In this study we focus on two specific transport alternatives with the potential for reducing both travel costs and emissions for local business trips and work commute: "car-sharing" and "ride-matching". Understanding the conditions under which these alternatives are acceptable as substitutes for taxi and drive-alone trips may be a useful guidance for finding efficient company policies to mitigate private car dependence. The results indicate a clear willingness for employees to adopt these more efficient alternatives based upon a few decisive factors. The study is also relevant from a traffic planning perspective, focusing on the potential of supporting and integrating company policy with respect to employees travel plans, as an effective traffic control measure.

Keywords: *car-sharing; ride-matching; company policy; sustainable travel; stated preference; econometric modelling.*

1. Introduction

1.1 Aim and background of this paper

The concept of "travel planning" is defined as "a package of measures developed by an employer designed to encourage their employees, visitors or customers to switch from driving alone to encouraging the use of more efficient and environmentally friendly forms of transport" (Newson, 2000). It has been shown that travel plans are effective measures from a societal and company perspective to obtain modal shift and mitigate peak-hour congestion (Rye and MacLeod, 1998, Coleman, 2000). However, in order to analyze the acceptability toward travel plans and the requirements for these to be successfully implemented, sophisticated statistical methods are needed (Modarres, 1993).

In the Netherlands travel planning has been part of national transport policy since 1989. Several solid empirical examples are also available from the UK and the US, where companies have implemented travel plans as effective company policies. In the UK, company travel plans are now part of governmental traffic policies (Rye, 1999). According to Coleman (2000), the most crucial task from a traffic management perspective is to convince employers that they should take responsibility for their staff's travel choices. As cited by Rye (1999), a common employer attitude remains: "Our responsibility to our employees starts and finishes at the factory door". As stated by Rye (2002), the most essential element for implementing travel plans is the companies' self interest, responding to the question 'what is in it for us'? As an example of this, Rye (1999) cites the following employer response: "In today's global market, you would only do this for two reasons: to cut costs or to improve your marketing advantage". A substantial and fast shift of travel habits from pure altruistic reasons is not to be expected.

New mobility management alternatives, (e.g. car-sharing) are examples of transport innovations that fit well into the technological and socioeconomic environment, and where the necessity for technological change is particularly evident (Prettenthaler and Steininger, 1999). According to this reasoning, one could expect that companies within the telecommunication sector would have double economic incentives to promote travel plans by both selling and using the services. By increasing the attractiveness and competitiveness of new intelligent transport systems through the development of efficient technological solutions (e.g. smart card technologies, real-time traffic information, booking systems), in conjunction with providing examples of the frontier use of these services, these companies could show how their technology can be applied to achieve both monetary savings and environmental gains.

Access to cars without ownership (e.g. car-sharing or ride-matching, supported by IT) is a trend-breaking example towards a sustainable traffic system. Some authors estimate that car-sharing, which might mitigate the strong dependency on private cars, will have an increasing role in the future with scarce fossil-, and renewable energy assets (Robèrt and Jonsson, 2006, Åkerman et al, 2000, Prettenthaler and Steininger, 1999). It also has the potential to reduce the number of idle cars and induces a faster replacement of old car parks to more efficient car models (Mont, 2004). According to Steninger et al. (1996), the three main environmental benefits are:

- *Changes in the incentive structure from using a private car.* Nearly all costs are turned into variable costs, making the individual face a higher relative cost for car use at each mode choice occasion. In owning a private car, much of the expense is paid for in fixed costs, regardless of whether or not the car is used.

- *Inducing modal split change.* Car-sharing has the potential of bridging the gap between private and public transport systems through one-way trip chains, including mixes of other transport modes. (This is supported by Huwer (2004).)

- *Reduction in number of cold starts.* As a result of the fact that many travellers share the same vehicle (approximately 15 due to Steninger et al. (1996)), the number of cold starts is reduced. This has a certain positive impact on the total amount of toxic emissions and greenhouse gas emissions per trip.

Yet another point could be added to Steninger's list:

- Because demand for private ownership is avoided, car-sharing may be helpful in the introduction of new technologies such as fuel cells or electric vehicles. This is seen in many car-sharing fleets already, even in Nacka Strand where this empirical study is carried out (one of the cars is a hybrid electric vehicle).

The idea of ride-matching is to coordinate car trips between drivers and potential passengers, travelling identical or similar routes. Naturally, this might lead to reductions both in travel costs and emissions. Kingham et al, (2001) addresses the problem of finding ride-matching partners as a severe obstacle to this service. However, ride-matching computer programs available could reduce this problem substantially (Dailey et al, 1999). Another problem is the discomfort of driving with unknown passengers. Höjer (2000) identifies this as the most severe obstacle for ride-matchers in a *public* ride-matching scenario. Perhaps this problem is less severe if the system is open only to employees from the same company or business district.

In order to estimate the potential substitution rate of car-sharing and ride-matching, we analysed the question from the user perspective (i.e. test the employees' attitudes). The research project was carried out in cooperation between the telecommunication company Ericsson, and the Royal Institute of Technology in Stockholm. The paper is structured as follows: in section 2 the method is reviewed, in section 3 and 4 the results from the study are presented and in section 5 we discuss our findings. Finally, the conclusions are presented in section 6.

2. Method

2.1 The survey and data

At the time of the study, the office area in Nacka Strand consisted of 230 000 m^2, containing approximately 150 companies with 7000 employees (Berg, 2003). The largest companies were the telecommunication companies Ericsson and Telia, having together approximately 2500 employees. Main transport modes to the area were car, taxi, bus, bicycle and boat. The number of vehicles passing in and out of Nacka Strand was approximately 8000/week (Lahti, 2003) (bicycles excluded) and the boat carrieed about 150 passengers per day on average (Hagbard, 2001).

We tested the willingness to choose car-sharing as a substitute for taxi for local business trips during office hours within Stockholm. Car-sharing was distributed to all companies in the business district, as an option to private car and taxi. Information and booking systems were managed on the web or via the employees' mobile telephones.

The local management of Ericsson in Nacka Strand made special requests to study also the hypothetical service of ride-matching. This would consist of a computer-aided system, distributed either on the internet or the company's intranet, in which employees would fill in their trip on a map and drivers and passengers would receive assistance in coordinating their trips. In this study, we tested the most essential element of such a system: the car drivers' acceptance to pick up passengers in their cars during work related travel.

The questionnaire included specially designed stated preference questions (see Louviere et al, 2000) in order to test the willingness to accept the new hypothetical alternatives. One section also covered preferences to telecommuting as a means to reduce commuter trips and the rental costs of office space (Robèrt and Börjesson, 2006). The employees at Ericsson received their questionnaires through the company's internal mail system. After answering, the questionnaires were sent anonymously to the reception desk.

In total, 521 response forms were distributed to all employees working at Ericsson in the office district. The response rate was approximately 55%. According to the managers at Ericsson in Nacka Strand, the response rate was considered high in comparison to previous surveys carried out. After cleaning the data (e.g. eliminating respondents who answered "don't know") some of the observations had to be omitted because they were incomplete. The attributes tested in the survey were chosen after carrying out a focus group interview and a pilot study in the sample.

Questionnaires were also distributed to 152 boat-commuters (those primarily using a commuting boat for trips to and from Nacka Strand). The response rate from this population was 70%. The reason for carrying out the analysis in both these two populations (Ericsson employees and boat-commuters) was in an attempt to determine if there were diversities in preferences towards car-sharing between the two groups.

Boat-commuters are considered as a choice-based segment of commuters in Stockholm, having adopted a quite exceptional commuting mode. As a consequence, one could theorize, *a priori*, that this group might have slightly different preferences regarding unconventional transport modes, of which car-sharing would be yet another example. In part, this could be partly because they represent a selection of people who are relatively open to change: changing habits regarding one travel mode may also break barriers to test other alternatives as well.

2.2 Choice modelling

To empirically test the potential users' acceptance of these alternatives, we used econometric modelling as a tool to estimate beforehand the employees' criteria for adopting these substitutes to taxi and drive alone in their cars. In this section we use car-sharing to explain the method applied for testing the acceptance of the services. The same theoretical framework is used for testing ride-matching.

We assume that the attributes mentioned in the previous section have an effect on the attractiveness of the car-sharing alternative, i.e. increasing the probability for choosing car-sharing instead of taxi. Examples of attributes used in this empirical study for car-sharing are presented in Table 1 below:

Table 1: *Examples of attributes affecting the choice between the two alternatives car-sharing and taxi.*

Examples of alternatives	Car-sharing or Taxi
Examples of car-sharing attributes	Monetary bonus (SEK) for using car-sharing Real-time traffic info in car-sharing (yes/no) Type of car (traditional, exclusive or electric)

In econometric modelling such attributes are used to formulate the individual's perceived utility from choosing the respective alternative. In this example we have the utilities $U_{car\text{-}sharing}$ and U_{taxi}. If varying the levels of the attributes (e.g. varying the monetary incentive "bonus", or altering the type of car), the utility for car-sharing can be changed. In this example we hold the attributes for taxi fixed, and assume that the respondent is familiar with the utility of this alternative, i.e. the respondents are assumed to be accustomed with taxi. The probability for choosing car-sharing instead of taxi could then be expressed as the probability that $U_{car\text{-}sharing}$ is greater than U_{taxi}:

$$P(car\text{-}sharing) = P(U_{car\text{-}sharing} > U_{taxi}) \qquad (1)$$

These utilities can be described as additive linear functions of the level of different attributes x_i (e.g. cost and travel time) and the preference parameters $ß_i$:

$$U = \alpha_i + ß_1 x_1 + ß_2 x_2 + \ldots + ß_k x_k + \varepsilon = V + \varepsilon_i \qquad (2)$$

Here *V* represents the *deterministic* or the measurable part of the utility, where the error term is excluded from the utility function. The coefficient α_i stands for the "alternative specific constant", also termed the "intercept parameter", compensating the utility function for hidden attributes, not included in the model. In this study we assume that the error term ε is IID Gumbel distributed, giving us logit models to estimate the preference parameters (Ben-Akiva and Lerman, 1985, Greene, 2000).

We express equation (2) in vector form as: $V = \boldsymbol{\beta} \cdot \boldsymbol{x}$, where $\boldsymbol{\beta}$ is the preference parameter vector and $\boldsymbol{x}$ the attribute vector, containing the proportions of attributes that we assume have an effect on the choice between the alternatives. The probability that individual *n* will choose alternative *i* is then given by the multinomial logit model:

$$P_{in} = \frac{e^{Vin}}{\sum_j e^{Vjn}} . \qquad (3)$$

In this paper we express the deterministic part of the utility function so that the attribute and preference parameters have the adherent variable names as indexes. Equation (2) would then be expressed as follows for car-sharing, containing three attributes:

$$V_{car\text{-}sharing} = \alpha_i + \beta_{bonus}\, x_{bonus} + \beta_{info}\, x_{info} + \beta_{cartype}\, x_{cartype} \qquad (4)$$

The impact of each attribute on the individual's choice decision is revealed from the magnitudes and the significance levels (t-values) of the *ß*-parameters. The *ß*-parameters indicate what people value most in the choice between the alternatives. Positive values of *ß* correspond to an increased utility related to that attribute (e.g. comfort attributes and monetary compensations), whereas negative values correspond to a disutility, (e.g. inconveniencies and costs). By explicitly analysing the *ratio* between the *ß*-parameters, it is possible to express the relative importance between these attributes. Our intention is to find the best-specified model, in order to derive the importance of the different attributes and make predictions on the choice probabilities between car-sharing and taxi.

If a variable has a significant t-statistic, the hypothesis that the variable does not have an impact on the individuals' choice decision could be rejected at that level (for example at a 95 % significance level). We also utilize two other statistics; the Akaike Information Criterion (AIC) and the Bayesian Information Criterion (BIC) to reveal the relevance of the chosen attributes, as both low AIC and BIC values imply good model specification, i.e. only relevant attributes are included in the utility function.[1]

[1] For derivation of these expressions see e.g. Englund (2000).

3. Car-sharing

In Stockholm, as in most other larger cities in Europe, there is a need to find strategies for more efficient urban mobility. Shared use of vehicles is an often-discussed alternative that may lead to relatively fast and cost-efficient effects related to traffic congestion and resource use. Given that these systems still have a rather low profile in society, it is important to investigate factors that facilitate or hinder a broader acceptance (Mont, 2004). At the time when the survey was conducted, only a small number of the respondents in our case study stated that they use the car-sharing facility. We tested the following research questions in order to investigate hypothetical conditions for a broader acceptance to car-sharing as substitute to taxi:

1. Was there at all a potential willingness to use car-sharing instead of taxi for local business trips in Stockholm, or will employees consistently prefer taxi? We tested the following four attributes as hypothetical incentives to the employees' acceptance of car-sharing, as a hypothetical substitute to taxi at local business trips:
   - *Electric vehicle* – this attribute would represent the employees' interest in alternative vehicles, where the electric vehicle is benign to the environment as opposed to the present "ordinary" car.
   - *A more exclusive type of car* (Volvo S80) – one assumption is that this might affect the employees' willingness to use the car-sharing alternative.
   - *Real-time traffic information* – we choose this attribute in order to test the impact from a purely technical IT contribution. The traffic-information system provides information on real-time route guidance including traffic disturbances such as road repairs and congestions.
   - *Monetary compensation* – the bonus attribute gives us some insight into the employees' valuation of the different attributes tested and is a monetary measure of the trade-off between car-sharing and taxi.

2. Were there certain socio economic segments in the population having significantly different preferences ("age", "income" and "sex"), and do the respondents' business trip habits affect the preferences (trip frequency and mode choice during these trips)?

3. Could boat-commuters, given their unconventional travel mode, be seen as a choice-based sample, having significantly different attitudes to car-sharing and the specific attributes tested? Here we controlled for socioeconomic variables in order to study the effect from the choice-based phenomena specifically.

In the model we tested for the probability to choose car-sharing instead of taxi, as dependent on the different attributes. Only people with driver's license were asked to answer. To make the hypothetical situation as realistic as possible, the respondents were first asked to imagine their last local business trip. After that, they were asked to respond to the following type of stated preference question. Here we provide an example of a stated preference question matched with a number of attributes that may influence the preferences:

What travel mode would you choose under the following conditions?

- The type of car-sharing vehicle is an ***electric vehicle***
- In the car-sharing vehicle there exists ***a real-time traffic information system***
- If choosing car-sharing, you will get a monetary compensation of ***X*** SEK

- ❑ I would choose taxi
- ❑ I would choose car-sharing
- ❑ I do not know

To make the comparison between car-sharing and taxi as simple as possible to the respondents, we assumed one-way-trips with car-sharing to be feasible in this hypothetical scenario. This means that the driver does not have to return the car-sharing vehicle to the place of departure, but instead leaves it at the destination. To implement this in reality, car-sharing must first reach a sufficient use rate so that vehicles do not get stuck at one place too long. According to the managers of car-sharing in Stockholm, the initialisation of this is planned for the future.

3.1 Results and model specification

In the total sample of both Ericsson employees and boat-commuters, only 3% of the respondents claimed they used car-sharing for their latest local business trip. Most used private car or taxi (67%). Nevertheless, in this study a majority (62%) stated that they would choose car-sharing in favour of taxi, on condition of the attributes presented in the survey. Only 19% choose taxi, and the rest “don’t know”. Thus, there seemed to be a potential willingness to choose car-sharing instead of taxi, on condition of the hypothetical attributes presented in the stated preference questions. We tested a number of different models in order to derive the importance of the various attributes. We also included three socio economic variables, and the variables for business trip patterns, to determine if these characteristics were significant in the choice between car-sharing and taxi.

The first model we tested consisted solely of the four different attributes:

$$V = \alpha_i + \beta_{electric}\, x_{electric} + \beta_{bonus}\, x_{bonus} + \beta_{exclusive}\, x_{exclusive} + \beta_{info}\, x_{info} \qquad (5)$$

Here “electric” is a dummy variable for if the car is an electric vehicle or not (assigned to 1 if electric vehicle and 0 otherwise). The variable “bonus” is the monetary compensation received for choosing car-sharing, “exclusive” is a dummy for the more exclusive type of car, and “info” is a dummy variable for traffic information in the car-sharing vehicle. The estimates are presented in car-sharing model 1 in the appendix.

The most significant attribute among the ones tested in this model was electric vehicle ("electric"), having a t-value of 2.3. Monetary bonus fell precisely below significance level with a t-value of 1.9. It appears that the respondents at Ericsson paid least attention to the two attributes "traffic information system" and "exclusive". In addition, these two attributes implied no improvements to the explanatory power of any of the model specifications we tested (revealed from the AIC and BIC-values). We therefore reject the hypotheses that any of these two attributes was important to the respondents at Ericsson, and continued our testing down of the best model without these two variables included.

Socio-economic variables and business trip patterns

To test for socio-economic effects we created a model consisting of three additional dummy variables ("income", "age" and "sex"), together with the two most significant attributes from the previous model ("electric" and "bonus"). Here we found the variable "age" significant (lower or higher than 35 years of age). The parameter value was positive, meaning that employees of higher age tend to choose car-sharing instead of taxi to a larger extent than younger employees. In this model even the bonus-parameter was significant. The variables "income" and "sex" are not statistically significant.

We next introduced two new dummy variables: 1) "owncar", revealing the respondents use of private car for the last local business trip, and 2) "trips", representing if the respondent travel more or less than one local business trip per month. Both variables were statistically significant. When including these in our model, "age" was no longer significant, meaning that this variable was irrelevant for the choice between car-sharing and taxi when controlling for these two variables concerning local business trip patterns. An examination of the AIC and BIC values indicated that the introduction of the two new dummy variables improved the model performance. A possible explanation to why age was significant in the previous model might be that age is positively correlated with car ownership, and negatively correlated with frequency of local business trips. From the lack of significance of the socio-economic variables, we concluded that these can be omitted from the model specification, and we instead formulate our final model as:

$$V = \alpha_i + \beta_{electric} x_{electric} + \beta_{bonus} x_{bonus} + \beta_{owncar} x_{owncar} + \beta_{trips} x_{trips} \quad (6)$$

This model includes three significant variables and had the best AIC and BIC values of all models tested (which would imply the best model specification). Also, the alternative specific constant (α_i) fell below the significance level, pointing at a better model specification. The estimates are presented in car-sharing model 2 in the appendix.

The t-value for electric vehicle (electric) was no longer significant. However, fewer respondents answered the questions concerning business trip habits, and therefore had to be omitted from the sample (i.e. the number of observations is reduced). So, since this attribute improves the AIC value, and is a policy-variable (i.e. a possible policy measure to introduce as an incentive for car-sharing), it was included in our final model. The monetary valuation of this attribute, in comparison to the “traditional car”, is 55 SEK, according to the parameter ratio between “electric” and “bonus”.

Prediction of choice probabilities and elasticities

After testing a number of models we choose the one having the best AIC value, and the highest number of significant variables. In Table 2 below, the predicted choice probabilities from this model are presented, as dependent on the variables “electric”, “bonus” and “owncar”. Here we fixed the dummy variable for frequency of local business trips (“trips”) to 1, i.e. the choice probabilities in Table 2 are valid *only* for employees travelling at least 1-4 local business trips per month.

Table 2: *The probability of choosing car-sharing as substitute for taxi among the Ericsson employees. The differences in probabilities (ΔP) can be used as approximate elasticity measures for the impact of the variables on the probability.*

electric	**Bonus**	**owncar**	**Probability**
No	0	No	**0,05**
No	50	No	**0,14**
No	0	Yes	**0,31**
No	50	Yes	**0,56**
Yes	0	No	**0,15**
Yes	50	No	**0,33**
Yes	0	Yes	**0,57**
Yes	50	Yes	**0,79**

In Table 2 above we present the impact of a bonus level of 50 SEK since this level of compensation might be considered reasonable from the company’s perspective. Evident from Table 2 is the three variables’ strong influence on the choice probability. When there is no electric vehicle, no bonus and the person did not drive own car at the latest business trip, the probability reaches only 5%, whereas by changing all variable values as in the lowest row, we got a probability of 79%. Using the levels of the variables and the differences in probabilities from Table 2 as approximate elasticity measures for the impact of the variables, we got an average ΔP for “electric” around 20%, ΔP for “bonus” around 19%, and ΔP for “owncar” around 40%. Apparently, from the levels chosen in Table 2, the variable for car use affected the choice probability the most, pointing at a larger propensity to choose car-sharing if the person is a car driver.

3.1.1 Results and model specification for the boat-commuters

When testing equation (5) on the boat commuters (car-sharing model 3 in the appendix), we uncovered some remarkable differences in results relative to the Ericsson employees. Firstly, if not including the attributes in the model (i.e. as today, without incentives) we found that boat-commuters were generally less resistant towards car-sharing than the Ericsson employees. In addition, the only significant attribute among the boat commuters was the traffic information system. Not even the monetary compensation (“bonus”) fell within the 95% significance level. Even “electric” fell substantially below the significance level. As for the Ericsson employees, we omitted the insignificant attributes and tested the model including all three socio economic variables (“income”, “sex” and “age”). According to the AIC and BIC values, this improved the model performance substantially. Age seemed to be the only significant socio economic variable, showing that older passengers have a higher tendency to choose car-sharing instead of taxi.

Thus, we constructed a model consisting entirely of the traffic information system and the age parameter:

$$V = \alpha_i + \beta_{info} x_{info} + \beta_{age} x_{age} \tag{7}$$

The estimates are presented in car-sharing model 4 in the appendix.

Prediction of choice probability, using our best model specification
This model showed the best AIC and BIC values of all models tested for boat-commuters. We used this model specification to generate probability predictions for the choice between car-sharing and taxi use among the boat-commuters. The probability predictions are presented in table 3 below:

Table 3: The *probability of choosing car-sharing, as substitute for taxi among the boat-commuters.*

	age <= 35	**age > 35**
no traffic info	**P=0,41**	**P=0,82**
traffic info	**P=0,68**	**P=0,93**

There was a substantial difference in probabilities between the younger and the older segments. The difference in probabilities was largest if having no traffic information in the car-sharing vehicle (ΔP reduces from 41% to 25% if adding a traffic information system to the car-sharing vehicle). Apparently, the traffic information system implied a substantial probability increase for both the younger and the older segments.

4. Ride-matching

Ride-matching is a service not yet implemented in the business district of scope, but top management at Ericsson would like to launch it in the near future. Regarding the choice between ride-matching and taxi we tested the following research questions:

1. Is there at all a potential willingness among drivers to pick up passengers during work commute or local business trips? We tested the following three attributes as hypothetical incentives to the employees’ acceptance of ride-matching, as an alternative to private car:
   - *Minutes of delay* – a ride-matching system might cause the driver a certain delay from picking up passengers. We test the sensitivity to waiting times by estimating the drivers’ value of time while waiting for passengers.

- *Type of passenger* – we test if it matters if the passenger works at the same company as the driver. Either the passenger belongs to the same company, or not necessarily to the same company but from the same business district. An assumption is that this would affect the drivers' willingness to pick up passengers.
- *Monetary compensation* – the drivers receive a certain monetary bonus for the possible inconvenience of picking up a passenger. The aim is to derive a feasible compensation rate, where drivers consider it worthwhile to pick up passengers in their cars. This is of relevance in plans to implement a ride-matching system where passengers share part of the travel costs.
- *Type of trip* – we assumed that ride-matching might be suitable for both local business trips and work commute, so we run the test for both these travel types to trace possible differences in results.

2. Are there certain socio economic segments in the population having significantly different attitudes towards picking up passengers in their cars ("age", "income", "sex", "children", "trips")?

The employees' stated willingness to use a ride-matching system was considered as a first criterion for implementing a ride-matching system in the business district. Of course, before implementation of a service of this kind, other aspects must also be considered, e.g. the passengers' criteria for participating and technical considerations regarding what kind of ride-matching system would be the most effective. Again we constructed stated preference questions in order to determine the criteria for the respondents' acceptance. Only employees using private car to work were asked to fill in this part of the questionnaire:

Would you pick up a passenger in you car under the following conditions?

- Pick up of passenger causes ***X*** minutes delay
- As a compensation for the inconvenience, you get a monetary bonus of ***Y*** SEK.
- The passenger ***works/does not work*** at your own company

- ❑ Yes
- ❑ No
- ❑ Do not know

4.1 Results and model specification

The ride-matching survey was handed out to Ericsson employees at Nacka Strand. A majority of the sample (57%) use private car to go to work. Our objective was to derive a model to predict car drivers' propensity to pick up passengers in their cars, as dependent on the selected attributes tested in the stated preference questions. We also tested models including the socio economic variables tested for car-sharing. An initial analysis of the choice distribution revealed that approximately half of the respondents (51%) answered: "yes, I would pick up a passenger under these conditions", 34% answered "no" and the rest "don't know". The answer to our first research question regarding ride-matching would be ‘yes’. It seems like there is room for a successful implementation of a ride-matching system given the drivers’ stated acceptance of picking up passengers. Our initial models treated work commute and local business trips separately in order to determine if respondents perceive these two types of trips differently.

4.1.1 Work commuting

We first analysed work commute in a separate model. In order to derive the most important attributes for accepting a passenger during this type of trip we formulated a model consisting solely of the following three attributes:

$$V = \alpha_i + \beta_{delay} x_{delay} + \beta_{bonus} x_{bonus} + \beta_{passenger} x_{passenger} \qquad (8)$$

All attributes in this model are significant and the estimates are presented in ride-matching model 1 in the appendix. The delay variable was the most significant, at $p \leq 0.001$. We then tested four socio economic variables (“sex”, “age”, “income”, “children”), but none was significant. We had expected that having children in the family would be an obstacle for picking up passengers on the way to work, since this might imply a higher need for trip chaining (related to trips via kindergarten and school) but this variable was not significant. However, the dummy variable for “age” (younger or older than 35) was close to significance (t=-1.8378), pointing at a possibly higher acceptance among younger drivers to pick up passengers. Women did not have a significantly larger aversion to pick up unknown passengers in their car during work commute than men (which was not the case for local business trips, see next section).

4.1.2 Local business trips

We then followed the same procedure for local business trips, first testing the impact from the three attributes in (equation 8). Since there are some characteristics distinguishing local business trips from work commute, we expect differences in the results between these two types of trips. Firstly, local business trips occur mostly during office hours, whereas work commuting takes place before and after actual work hours. Secondly, being able to pick up a passengers during work commute implies having information about the passenger’s residential location, which might be perceived as a safety factor, reducing the passenger’s level of anonymity. As for work commuting, the aim is to test the best model specification, and search for the most significant attributes. Again we began our modelling effort by including only the three attributes “delay”, “bonus” and “passenger” (equation 8). The estimates are presented in ride-matching model 2 in the appendix.

In contrast to work commute, the dummy variable for if the passenger belongs to the same company or not (“passenger”) is not significant, showing that in average, to the respondent, it does not matter if the passenger is from the same company or not for local business trips. However, when we included the four socio economic variables, “sex” was significant, indicating that women had a significantly larger aversion to pick up passengers during local business trips than men. As stated in the previous section, this dummy variable was clearly not significant for work commute, with a t-value of only – 0.065. In accordance to work commute, we found no significance for "age", "income" and "children". Even a dummy variable for frequency of local business trips turned out insignificant.

4.1.3 Prediction of choice probabilities and elasticities

Having uncovered coherent results from the two types of trips regarding the three attributes, we included data from both work commuting and local business trips in order to maximize the sample size when estimating the influence of the attributes on the choice probabilities. In this final model specification all three attributes were significant, so they were all included in the probability predictions. The choice probabilities for picking up passengers, as dependent on the three attributes, are presented in table 4 below:

Table 4: *Drivers' average probabilities for picking up passengers in their cars, estimated over the total population of Ericsson employees in Nacka Strand. The differences in probabilities between two cells can be used as approximate elasticity measures (ΔP).*

Delay	**Bonus**	**passenger**	**Probability**
10	0	not same	**0,21**
10	50	not same	**0,39**
10	0	same company	**0,32**
10	50	same company	**0,52**
5	0	not same	**0,36**
5	50	not same	**0,56**
5	0	same company	**0,49**
5	50	same company	**0,69**

In Table 4 we see the model prediction of drivers' probabilities for picking up passengers in their cars, as dependent on the attributes tested. Evidently, all three of the attributes ("delay", "bonus" and "passenger"), had a certain impact on the probability of accepting a passenger. If we use the levels of attributes and differences in probabilities from Table 4 as approximate elasticity measures for the impact of the attributes, we derive an average ΔP for delay around 17%, holding the other two variables fixed. The same calculation for bonus gives ΔP around 20%, and ΔP around 13% for type of passenger. We see that from the levels of attributes chosen in Table 4, ΔP is about the same magnitude for all three variables. It may be observed from Table 4 that there is a substantial diversity in probabilities between the least favourable case (upper row) and the most favourable case (lowest row), where the difference in probabilities ranges from 21% to 69% (ΔP = 48%). In order to make the system work in reality it would be advisable to try to create a system including not more than one attribute at the "worse" level in table 4, implying a choice probability at least around 50%.

5. Discussion

5.1 Car-sharing

There is a substantial discrepancy between the low use rate of car-sharing at present, and the positive attitudes toward this approach as revealed in the survey. One explanation is of course that the hypothetical car-sharing alternative in the study really is more attractive than the current real alternative. Firstly, the hypothetical alternative has the attractive one-way feature, implying no obligation to bring the car back to the place of departure (which the current real alternative has not). This is obviously making the service more competitive but could be realized only if car-sharing reaches a broader acceptance in society. Several respondents have commented that this feature is a necessary condition for choosing car-sharing at all. Secondly, in each stated preference question, car-sharing is presented together with a bundle of "incentives" (new types of vehicles, traffic information, or monetary compensations), making it more attractive than in reality. Furthermore, a substantial reason for the low use rate at present might be the poor level of information and lack of promotion of the car-sharing alternative to employees. Several respondents expressed their surprise that car-sharing existed as an option in their office area. Another reason would be the general dilemma with stated preference questions. The questions are only perceived as hypothetical, which could result in a tendency to overrate what one *should* and/or *could*, in relation to what one really *would*. However, the relative importance of various attributes is informative, and it is possible that these *relationships* would be similar in reality even if the actual numbers would be different.

When comparing the results from the Ericsson employees and boat-commuters there are several concurring results, but also some substantial differences. To begin with, the boat commuters were in general more favourably disposed to car-sharing than the Ericsson employees. The clear deviation in preferences between the two populations regarding the two attributes "electric vehicle" and the "traffic information system" was noteworthy. Apparently, the Ericsson employees considered the electric vehicle, together with a monetary compensation, to be clear incentives for choosing car-sharing. The attractiveness of the electric car is verified in practice from the managers of car-sharing in Nacka Strand, where an electric car was recently introduced.

The boat-commuters on the other hand, considered the traffic information system as the most important attribute. In comparing the modal split for local business trips among Ericsson employees and boat-commuters we see that there is a larger proportion of car users at Ericsson (70%), than among the boat-commuters (45%). This may explain some of the differences in tastes related to the two attributes "electric" and "info". A car driver might have a larger interest in testing a new type of car (electric) and might be more experienced in finding his way in traffic, implying a reduced need for the traffic information system. We even tested the boat commuters' willingness to pay for a certain real-time positioning/delay system to the boat, together with trip frequency and ticket price (see boat model and results in the appendix). As for the IT-attribute in the car-sharing vehicles, the boat commuters showed a significant interest even to this IT-service. Perhaps the need for the IT-service in the boat has made the boat-commuters appreciate the relevance of traffic information even in the car-sharing vehicles.

Neither of the two populations had a significant preference for the more lavish type of car. According to the focus group, more expensive cars in the car-sharing fleet would increase their interest for this alternative. Perhaps the car type tested in this survey was not fancy enough, or the focus group was not representative of the whole test sample with respect to this issue. Nevertheless, looking at the cross tabulation between choice-distribution and type of car, one could suspect that this attribute would increase the attractiveness for car-sharing (Figure 1).

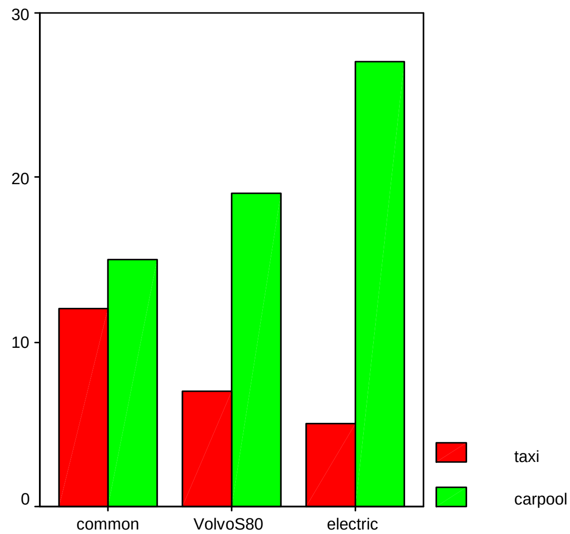

Figure 1. *Cross tabulation of the choice distribution between taxi and car-sharing as dependent on the three types of car.*

Monetary compensation was found significant for the Ericsson employees, but not for the boat-commuters. Perhaps this indicates a more cost-minded population at Ericsson.

The modal split between the two populations does not explain why there is a stronger preference towards car-sharing among the boat-commuters than among the Ericsson employees (tested in the model comparing the two populations). Because testing the attribute “owncar” among the Ericsson employees revealed even a more positive attitude to car-sharing among car drivers than other commuters, the relationship between Ericsson employees and the boat-commuters would have been the opposite due to that. Both these results indicate that the boat-commuters, in some sense, perceive themselves as “frontier commuters”, more open minded to new alternative travel modes, more able to better utilize advanced technology. Perhaps the boat-commuters’ adoption of a new unconventional travel mode (the boat) might open doors to even more alternatives? This possibility may have some significance for the way business corporations plan for the future regarding travel planning. What staff may not adopt immediately may very well be adopted later on as people become more experienced in testing new travel alternatives. The variable “age” was significant in the boat population and in the pooled population (both Ericsson employees and boat-commuters), pointing to a higher acceptance to car-sharing in the older segment. In some sense, this contradicts the prejudice that older people would be more rigid in their decisions, having stronger barriers towards car-sharing.

5.2 Ride-matching

The results of this hypothetical service show that there was a strong sensitivity to the attribute "delay". This parameter had the only highly significant value ($p \leq 0.001$). Figure 2 below shows a cross tabulation of the choice distribution as a function of minutes of time delay:

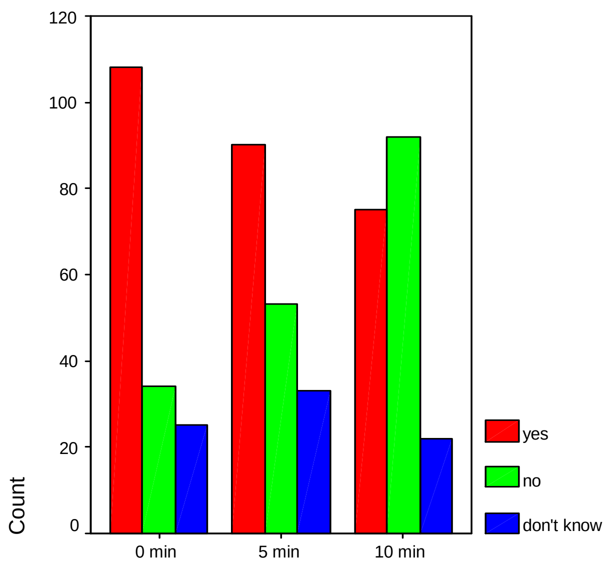

Figure 2. C*ross tabulation of the choice distribution and the minutes of delay in a ride-matching system.*

From this graphic we expect that the system will have severe difficulties in being adopted by private car drivers if it can not overcome the problems of time delays that passengers might cause. Of course waiting times could be economically compensated (as demonstrated in Table 4). As a consequence, time delays reduce the margins of an economically successful implementation of a ride-matching system. Also, at least in Sweden, there may be other problems associated with taxation rules (which of course is an institutional matter).

When comparing the valuation of time for the time delay, we find relatively high values, pointing to a substantial disutility for increased travel times caused by passengers. We also discover a slightly higher value of time for work commute (9.7 SEK/min), than for local business trips (7.2 SEK/min). This might be explained given that work commuting is done during non-office hours, whereas local business trips are not, and that employees in general have slightly different valuations of leisure time and work time. Another explanation might be the fact that the road network is less densely occupied during office hours (during which local business trips occur), and that these trips therefore imply less stress due to delays, resulting in a lower valuation of time.

Another clear difference between the results from the two types of trips (work commute and local business trips) was the variable for type of passenger. It appears that the respondents pay more attention to whether or not the passenger belongs to the same company at work commute than during local business trips, since “passenger” is only significant in ride-matching model 1 (see appendix). The fact that women in the sample tend to have a larger aversion than men to picking up passengers during local business trips may be explained by the fact that during work commute, there is a higher chance of sharing a ride with a neighbour or someone living fairly close (i.e. the security arises from a better control of where the passenger lives).

One of the respondents gave us a hint of yet another obstacle for picking up passengers in the car: *”To a large extent, I use my private car trips for private telephone calls, which I don’t want to share with colleagues”.* Certainly there are several other hidden factors that affect acceptance of picking up passengers when confronted with the situation in reality. Obstacles such as constraints related to family life, temporary stress in working conditions, and errands during work trips might all contribute to weakening the prospects of such a system. Certainly there is a risk that the respondents did not take all such preventing factors into account when answering these hypothetical questions. However, the probabilities in Table 4 are fairly high, offering room for somewhat lower actual figures, at least if implementing this service in a larger business district (e.g. Kista, having more than 10 000 employees). According to the predictions, at least half of the respondents *say* they would cooperate, if at least two of the attributes were kept on the more favourable levels.

As discussed in the introduction, past research concludes that environmental gains are to be expected when incorporating these travel mode changes at a larger scale in the traffic network. In addition, monetary savings might go hand in hand with the emission reductions (Fellows and Pitfield, 2000). Companies at Nacka Strand (Lahti, 2003) have calculated substantial monetary savings from using car-sharing instead of taxi for one of the most frequent local business trips (Nacka Strand – Kista). Ride-matching during local business trips might result in even larger economical savings to the company’s travel expenses. Travel habits at work-commute, on the other hand, do not bring direct monetary savings to the company (in comparison to local business trips). However, companies encouraging more efficient alternatives for work commuting (e.g. investing in ride-matching systems) help their employees to cut private travel expenses. This could in a way be perceived as a benefit to employees, improving the attractiveness of working in the company. It might also help improve the company’s environmental profile and public relations.

6. Conclusions

At the time when this study was conducted, shared vehicle use, such as car-sharing and ride-matching, had not yet reached a substantial impact on the urban traffic system in Sweden (in comparison to e.g. Germany, Austria, Switzerland or Singapore). However, our overall conclusion from this study is that more direct incentives and company policies (e.g. considering incentives such as some of the attributes tested), may encourage a shift towards more efficient transport alternatives, resulting in a significant effect on the companies' travel expenses. A business district the size of Nacka Strand might even be in the position to put pressure on the external, municipal or governmental levels by demanding new institutional regulations and tax-exemptions helping the companies to a more profitable implementation of travel plans. Consequently, it is likely that companies could play a vital role in the discussion of feasible paths towards a more sustainable transport system.

Nevertheless, one should not underestimate the inertia related to changing individual behaviour—"old habits die hard". For instance, in the study of the ride-matching system, we found that the most important variable seemed to be the time-delay, caused by picking up and dropping passengers. This points at the problem of first reaching a "critical mass" of use-rate in such a system, to reduce time-delays before it is generally accepted and efficient. It is therefore likely that such systems would need subsidies, tax exemptions and other incentives, especially during the start-up phase in order to eventually become self-propelled.

In the specific case of technology-driven companies (such as in Nacka Strand), sustainability initiatives could be incorporated with development and promotion of attractive IT-solutions in order to show effective examples of the use of own technology. Consequently, this could lead to additional market advantages, where information technology could work as a "logistic lubricant", facilitating the introduction of more efficient mobility management alternatives.

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Appendix

Variable declarations

Car-sharing models

“α_i”	alternative specific constant
“electric”	electric car-sharing vehicle
“bonus”	monetary bonus for choosing car-sharing
“exclusive”	dummy for if the car-sharing vehicle is exclusive, here a VolvoS80
“info”	dummy for if the car-sharing vehicle is equipped with a traffic information system
“owncar”	dummy for if the respondents have an own car or not
“trips”	dummy for local business trip frequency higher or lower than once/month
“age”	lower or higher than 35 years of age
“boat”	if the respondent is a boat-commuter or not
“sex”	dummy for man or woman
“inc”	dummy for income higher or lower than 40 000 SEK/month
“public”	dummy for if the respondent used public transport at the latest local business trip

Ride-matching models

“α_i”	alternative specific constant
“delay”	number of minutes delay caused by picking up passenger
“bonus”	monetary bonus for picking up a passenger
“passenger”	dummy for if the passenger belongs to the same company or just from the same business district
“triptype”	dummy for if the type of trip allude to work commute or local business trips
“trips”	dummy for if the respondent work commute at least five times / week or less
“age”	lower or higher than 35 years of age
“sex”	dummy for man or woman
“children”	dummy for if the respondent has children in their family

Boat model

“IT-service”	web-based positioning system and SMS
“tripfrequency”	the boats hourly tripfrequency
“price”	ticket price

Model estimates

Car-sharing models

Parameters	Model 1	Model 2	Model 3	Model 4	Model 5
α_i	-0.30	-1.28	0.80	-0.37	-1.20
	(-0. 60)	(-1.62)	(2.12)	(-0.74)	(-2.00)
electric	1.5	1.10	-0.20		
	(2.33)	(1.63)	(-0.40)		
bonus	0.013	0.021	0.0072		
	(1.91)	(2.52)	(1.44)		
exclusive	0.85		0.056		
	(1.41)		(0.11)		
info	-0.19		1.03	1.12	
	(-0.33)		(2.14)	(2.11)	
owncar		2.05			0.67
		(2.90)			(1.60)
trips		-1.59			-0.94
		(-2.48)			(-1.91)
age				1.90	1.73
				(3.58)	(3.81)
public					1.11
					(1.99)
sex					0.66
					(1.65)
inc					-0.041
					(-0.099)
boat					1.18
					(2.49)
LLvalue	-45.61	-35.53	-81.27	-66.97	-107.94
AIC	0.59	0.49	0.51	0.44	0.50
BIC	0.65	0.55	0.54	0.46	0.55

Ride-matching models

Parameters	Model 1	Model 2
α_i	0.26	-0.029
	(0.60)	(-0.066)
Delay	-0.17	-0.11
	(-4.85)	(-3.08)
bonus	0.018	0.016
	(2.40)	(2.24)
Passenger	0.66	0.47
	(2.15)	(1.59)
Llvalue	-136.78	-141.45
AIC	0.61	0.66
BIC	0.63	0.69
Nobs	232	220

Boat model

Parameters	model
α_i	-0.60
	(-2.86)
IT-service	0.85
	(4.35)
tripfrequency	-0.12
	(-10.12)
price	-0.035
	(-5.06)
LLvalue	-168.96
AIC	0.40
BIC	0.42
Nobs	428