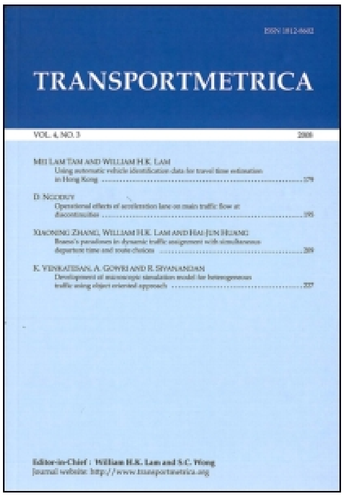

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The effect of Advanced Traveller Information Systems on public transport demand and its uncertainty

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Advanced Traveller Information Systems (ATISs) include a broad range of advanced computer and communication technologies. These systems are designed to provide transit riders pre-trip and real-time information, to make better informed decisions regarding their mode of travel, planned routes and travel times. ATISs include in-vehicle displays, terminal or wayside based information centres, information by phone or mobile and internet. In this article, a Stated Preference survey has been carried out in order to know the preferences of public transport's customers related to different ATISs and their willingness to pay in Palermo. An ordered probit demand model has been calibrated to determine the potential additional share of demand attracted by the adoption of ATISs. Finally, Monte Carlo simulation has been carried out to appraise the uncertainty on some parameters of the calibrated demand model. The results show that respondents give more importance to the type of information and its cost, whereas they are less interested in the system that provides the information.

Keywords: Advanced Traveller Information Systems; ordered probit demand model; Monte Carlo simulation; uncertainty

1. Introduction

Public transport information plays an important role in the accessibility of transit services. In the past few years, the application of communication technologies in transportation has allowed the development of several innovative services and fleet management, such as Automatic Vehicle Monitoring System (AVMS), which allows one to communicate in real-time to the Control Centre the exact vehicle's position and various other parameters of each vehicle as load condition on board, vehicle diagnostic conditions (check of the engine and closure of doors). The main task of the Control Centre is to check the positions on the road network of the transit fleet with respect to scheduled ones at the bus stops.

Furthermore, the AVMS allows whole control of the bus fleet in real-time, improving quality service under the following aspects:

- to check any non-recurrent events (incidents, dangerous situations, etc.), taking the right decision to keep a high service level by on-line fleet management data;

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- to plan a demand-oriented service (routes, frequencies, etc.) by off-line fleet management data;
- to up-date pre-trip and en-route information provided for customers, such as forecasted arrival/departure time at the bus stop, by using various communication devices (mobile phone, variable message sign at bus stops for en-route information, web-site and e-kiosk for pre-trip information).

Often the AVMS includes an Advanced Traveller Information System (ATIS), which provides up-date pre-trip and en-route information to transit users.

Now, transportation companies are able to control in real-time the service provided and to take the right decision when any unpredictable event occurs. The average arrival time at a bus stop can be estimated with a low margin of errors thanks to the knowledge of the exact position of each vehicle, the relative route and the current traffic conditions. This information is very useful for the customers, because they might be informed in real-time when their bus is expected to arrive at the relevant bus stop. Real-time information is very common in modern public transport companies.

Recently, Dziekan and Kottenhoff (2007) show the main effects of the AVMS and ATIS: reduced wait time, positive psychological factors, such as reduced uncertainty, simplified use and a greater feeling of security, increased willingness to pay, adjusted travel behaviour, such as better use of wait time or more efficient travelling, mode choice effects, higher customer satisfaction and better image.

There are several systems and different typologies of en-route information which are able to reduce the perceived irregularity of the public transport service (i.e. waiting time at the bus stop), especially, in urban areas, where the public transport service is influenced by private mobility (Nijkamp *et al*. 1996). Actually, public transport companies are not able to sustain the necessary cost to implement ATISs without the knowledge of the effects on customers' demand. Moreover, it is hard to understand which ATIS device/technology and type of information is preferred by customers.

Polak and Jones (1993), under the DRIVE European Project, studied the effects of pre-trip information on travel behaviour using a stated preference approach in Birmingham and Athens. The analysis revealed firstly, a requirement for multimodal pre-trip travel information even if the sample studied were regular car users, and that the quantity and type of pre-trip information requested by travellers depends on a range of personal, journey related, contextual and national factors. Moreover, they emphasised the importance to travellers of the timeliness and relevance of the provided information especially when relevant network incidents happen.

Abdel-Aty *et al*. (1996) studied the effects of ATIS on route choice by stated preference analysis achieving a reduction of travel time uncertainty. Also, Abdel-Aty *et al*. (2001) studied the commuter propensity to use transit with a computer-aided telephone interview conducted in Sacramento and San Jose, California. The results indicated that approximately 38% of the respondents who currently do not use transit might consider public transport if the appropriate information is available. Moreover, using an ordered probit model produced results that show the significant effect of several commute and socioeconomic characteristics on the propensity to use public transport.

Nijkamp *et al*. (1996) conducted a survey before and after the application of ATIS in the city of Birmingham and Southampton (QUARTET and STOPWATCH project respectively). Due to the early development of the QUARTET project their result was considered inconsistent, whereas in the city of Southampton the survey revealed a rise in using public transport, especially, in study and leisure trips, and mobility optimisation of people in choosing the mode and route able to reduce travel time. A methodology was developed by Mishalani *et al.* (2000) aiming to understand the effect of real-time information on bus stops, under three different methods to forecast bus stop arrival time: (1) static information, (2) real-time information up-date using historical data, (3) real-time information using data coming from an Automatic Vehicle Location (AVL) system. Measures of the difference between predicted and effective waiting time when people approach a bus stop showed that the third method revealed to be more reliabile than the other two methods.

Several authors analysed the commuters' behaviour under ATIS environment, in particular travel time and route choice, such as Hickman and Wilson (1995). Molin and Timmermans (2006) evaluated the willingness to pay for additional information through web enabled public transport information systems, whereas, Grotenhuis *et al.* (2007) investigated the desired quality of integrated multimodal travel information in public transport. Polydoropoulou and Ben-Akiva (1998), Lappin (2001), Chorus *et al.* (2007) showed that the information acquisition can be explained by behavioural factors. In particular, Chorus *et al.* (2007) discussed travellers' need for personalised and more advanced types of travel information. Furthermore, Chien *et al.* (2007) and Tan *et al.* (2007) setup decision support systems: the former to provide real-time pre-trip information on bus arrival times; whereas the latter to find a reasonable path in transit networks validated by a survey.

The impacts of benefits and technical performance of communication technology application in the city of Helsinki was studied by Lehtonen and Kulmala (2002). The system provided several public transport telematics, such as real-time passenger information, bus and tram priorities at traffic signals and schedule monitoring. Before and after field studies, an interview and survey, a simulation and socioeconomic evaluation indicated a 40% reduction of delay at signals, improving on regularity and reliability of public transport, reductions of 1–5% in fuel consumption and exhaust emissions. Moreover, the information systems were regarded very positively, and, in particular the information displays at stops were considered necessary. Similarly, Luk and Yang (2002) showed the benefits of ATIS application in Singapore.

In this context to address the potential demand of ATISs and to know the preferences of public transport's customers related to different ATIS device/technologies, we have developed a Stated Preference survey carried out by the submission of a questionnaire in the city of Palermo, located in South Italy. In particular, an original approach has been used to design a Stated Preference survey aiming to investigate whether real-time information would increase the use of public transport. The original aspects of the survey concern the concurrent presence of ranking and rating in the questionnaire and thus in answers of respondents. The aim is to understand which ATIS scenario is preferred in Palermo and potential increase in transit use. An ordered probit demand model has been calibrated to determine the potential additional share of demand attracted by the adoption of ATISs. The calibrated ordered probit model showed that travel by public transport, income and education are factors that contribute significantly to the likelihood of using public transport for given information provided. In general, the analysis showed a promising potential of ATIS in increasing the use of transit as a commute mode, reducing travel and waiting time. Furthermore, another original aspect regards the sensitivity analysis carried out by a Monte Carlo simulation to appraise the uncertainty on some parameters and to evaluate the robustness of the calibrated demand model to parametric variations.

The article has the following structure: the next section describes the ATIS scenario; the description of ordered probit model is included in Section 3; Section 4 presents the results; the analysis of uncertainty by Monte Carlo simulation is proposed in Section 5 and the last section discusses conclusions.

2. ATIS scenarios

Actually, there are several ATISs, which provide different typologies of information on various stages of a trip: at home/office (pre-trip), at a bus stop, on a public transport vehicle (on-trip). In the past, due to the high costs of ATISs and lack of knowledge of the real effects of ATISs, the main public transport companies were reluctant to adopt information systems. Moreover, since the transport service in urban areas suffers from cyclical variation in the traffic conditions, the provision of reliable service information, especially on not reserved routes, may become extremely difficult. Furthermore information errors, for instance, on predicted arrival time at the stops can result in a low perceived quality of service decreasing the demand share, for transit customers.

In the past few years, the evolution of informatics, telecommunication and the decrease in price of these technologies have encouraged public transport companies to invest in AVL and ATIS providing a more competitive and efficient service in order to attract more customers. These processes also have several social benefits: less congested cities, easier accessibility of public transport and reduced travel time, more sustainability of the transport system.

In this article, a Stated Preference survey was built and submitted by a questionnaire to a fit sample of population of Palermo, in order to know which combination of ATIS, typology of information and willingness to pay are preferred. At the time of analysis, no real-time information were provided by Local Public Transport Company (AMAT). The survey was conducted in late 2005 using a mail-back self-completion questionnaire, for further details see Amato (2006).

The first step in the design of the questionnaire was to identify the attributes most significant for our analysis, taking into account different ATISs, different typologies of information and their cost. We also considered pre-trip and on-trip information systems, the importance of real-time information, and willingness to pay by the customers. Thus, the selected attributes were

(1) information device/technology;
(2) information type;
(3) information cost.

For each attribute we took into account four levels. The levels of the former attribute were:

- display at bus stops;
- web-site;
- short message systems;
- call centre.

The levels related to the information type attribute were:

- waiting time;
- travel time;
- route choice;
- general information on service (i.e. next stop).

For the last attribute we considered the following four levels:

- free of charge;
- 30 cent/€ for single enquire;
- 20% more expensive tickets;
- 5€ of monthly subscription.

Levels of all attributes are synthesised in Table 1.

The full factorial design provides $k^n = 4^3 = 64$ different scenarios (where n is the number of attributes and k is the number of levels). Thus, assuming the irrelevance of interactions between attributes we reduced, according to the technique of Kocur *et al.* (1982), to 16 different scenarios (fractional factorial design). We divided these 16 scenarios into two groups (questionnaires A and B) in order to avoid fatigue effect in respondents as the literature suggests (Permain *et al.* 1991, Table 2). Some of these scenarios were not realistic (i.e. display at the bus stop can provide only the waiting time and with additional cost of ticket or free charge). Thus, these scenarios were modified and for this reason some scenarios are equal in both the questionnaires A and B.

In the questionnaire, we asked the decision makers, firstly, to select the four most preferred scenarios, then to order these four selected scenarios from most to least preferred (ranking), and finally, to evaluate the additional share in choice to use public transport mode, of four scenarios in an ordinal scale (rating). It was asked, how much the chosen scenario will increase their use of public transport (much, enough, not much, nothing, N/A). Some other information was also collected: frequency of use of bus and private vehicle, evaluation of the importance of some factors in choosing whether or not to travel

Table 1. Levels of the attributes.

Numerical values	Information device/technology	Information typology	Costs
1	Display at bus stops (*on trip real-time information*)	Waiting time	Free of charge
2	Web-site (*pre-trip real-time information*)	Travel time	30 cent/€ for single enquire
3	Short Message Systems (*on-trip and pre-trip real-time information*)	Route choice	20% more expensive tickets
4	Call centre (*on-trip and pre-trip real-time information*)	General information	5€ of monthly subscription

Table 2. Scenarios of the fractional factorial design.

Scenario	Information device/technology	Information typology	Costs
1	Display at bus stops	Waiting time	Free of charge
2	Call centre	Travel time	Free of charge
3	Display at bus stops	Waiting time	20% more expensive ticket
4	Web-site	Route choice	20% more expensive ticket
5	SMS	General information	20% more expensive ticket
6	Call centre	Waiting time	30 cent/€ for single enquire
7	SMS	Travel time	5€ of monthly subscription
8	Web-site	Waiting time	5€ of monthly subscription
9	Display at bus stops	Waiting time	Free of charge
10	Web-sites	General information	Free of charge
11	SMS	Route choice	Free of charge
12	Display at bus stops	Waiting time	20% more expensive ticket
13	Call centre	General information	20% more expensive ticket
14	SMS	Waiting time	30 cent/€ for single enquire
15	Web-site	Travel time	30 cent/€ for single enquire
16	Call centre	Route choice	5€ of monthly subscription

using private and public transport, some transport habits (frequency, reason, purpose and maximum distance travelled for the following transport modes: walking, bicycle, motorcycle, car as passenger and as driver, taxi, bus, tram underground), knowledge and use of real-time information and some socioeconomic information (Ortúzar and Willumsen 2001).

The original aspects of the survey concern the concurrent presence of ranking and rating in the questionnaire and thus in answers of respondents. We submitted 1000 questionnaires (whose 860 correctly compiled) to a stratified sample of citizens chosen among potential transit users (as students, employees, etc.), who have easy access to the internet and are experienced in ICT (mobile phone, computer, etc.). This could explain the high response rate. Furthermore, the width of interviewed sample is approximately 2.15%, considering a universe of about 40,000 transit users per day (related to an average share of 15% in transit modal choice in Palermo, ISTAT 2006).

3. Ordered probit model

When the dependent variable has a natural order and assumes more values, from the literature the ordered probit model should be more appropriate (Zavoina and McKelvey 1975, Khattak *et al.* 1992).

The dependent variable is expressed as

$$y_i^* = \beta' x_i + \varepsilon. \tag{1}$$

Let y^* be the dependent variable coded by $0, 1, 2, \ldots, J$, β is the vector of coefficients, x_i is the vector of the attributes and ε is the random term, normally distributed $N(0, 1)$.

The observation of the dependent variable is as follows:

$$
\begin{aligned}
&y = 0 \quad \text{if } y^* \le \mu_0\\
&y = 1 \quad \text{if } \mu_0 \le y^* \le \mu_1\\
&y = 2 \quad \text{if } \mu_1 \le y^* \le \mu_2\\
&\ \ \dots\\
&y = J \quad \text{if } y^* \ge \mu_{J-1}
\end{aligned}
\tag{2}
$$

where μ_j are the threshold values that together with β parameters have to be estimated by the calibration process. The ordered probit model provides the thresholds which indicate the levels of users' preference related to ATISs, without the need to make assumptions about the differences between the categories of the dependent variable. The threshold values have to be ordered from the lowest to the highest. The probabilities are provided by normal distribution:

$$
\begin{aligned}
&\text{Prob}[y = 0] = \Phi(-\beta' x),\\
&\text{Prob}[y = 1] = \Phi(\mu_1 - \beta' x) - \Phi(-\beta' x),\\
&\text{Prob}[y = 2] = \Phi(\mu_2 - \beta' x) - \Phi(\mu_1 - \beta' x),\\
&\ \ \dots\\
&\text{Prob}[y = J] = 1 - \Phi(\mu_{J-1} - \beta' x).
\end{aligned}
\tag{3}
$$

For all the probabilities to be positive, we must have

$$0 < \mu_1 < \mu_2 < \cdots < \mu_{J-1}.$$

Therefore, the probabilities that y_i falls into the j-th category is given by

$$\text{Prob}[y_i = j] = \Phi(\mu_j - \beta' x_i) - \Phi(\mu_{j-1} - \beta' x_i). \tag{4}$$

The ordered probit model includes two sets of parameters. The constant and other threshold values indicate the range of the normal distribution related to specific values of explanatory variables. The β parameters represent the effect of changes in any explanatory variable on a given scale. These parameters let us understand the relative importance of any variable in the choice process of ATISs. It should be noted that the signs of coefficients in the ordered probit model are particularly important since they provide different effects on the probabilities of the ordered categories.

4. Results

The ordered probit model was calibrated by Limdep® software, whose results are summarised in Table 3. We found that *cost* and *info* are the attributes that are more important (higher coefficients), whereas *device/technology* is less important, highlighting a good significance of p-values. It should be noted that the constant and device/technology have low significance. The probabilities of 16 scenarios are shown in Table 4 where the $\text{Prob}_i\ [y = 1]$ is the probability that the scenario $i = 1, \dots, 16$ is at the first place and so on for other probabilities. It should be noted that the best scenario is characterised by bus stop display, providing waiting time without any additional cost. Moreover the

Table 3. Calibration of the ordered probit demand model by Limdep software.

Attribute	Coefficient	Stand. Error	*b*/Stand. Error	*p*-values	Mean of *X*
Constant	0.2809	0.3655	0.769	0.4421	
Devices/Tech.	0.5826E-01	0.2734E-01	2.130	0.0331	1.500
Info	0.2685	0.3251E-01	8.259	0.0000	1.156
Cost	0.6333	0.4399E-01	14.397	0.0000	1.234
Bus freq.	0.2476E-01	0.1225E-01	2.020	0.0034	2.455
Internet use	−0.1670	0.5904E-01	−2.829	0.0047	0.662
Threshold values					
μ1	0.5691	0.1880	3.022	0.0025	
μ2	0.9568	0.1853	5.141	0.0000	
μ3	1.261	0.2075	6.039	0.0000	
SD	0.1239E-08				
Log likelihood function		−2556.018	$\chi^2[5] = 788.2$	Significance $(\chi^2) = 0.000$	

Table 4. Probabilities of 16 scenarios.

Questionnaire	Scenario	Prob [$y=1$] (%)	Prob [$y=2$] (%)	Prob [$y=3$] (%)	Prob [$y=4$] (%)
A	1	18.47	13.35	6.46	61.73
A	2	9.66	11.74	9.13	69.47
A	3	1.72	4.36	5.82	88.09
A	4	0.32	1.28	2.35	96.05
A	5	0.11	0.55	1.19	98.14
A	6	4.89	8.44	8.54	78.13
A	7	0.08	0.42	0.95	98.54
A	8	0.24	1.01	1.95	96.80
B	9	18.47	13.35	6.46	61.73
B	10	4.35	7.90	8.29	79.46
B	11	6.63	9.93	9.05	74.40
B	12	1.72	4.36	5.82	88.09
B	13	0.09	0.47	1.04	98.40
B	14	5.50	9.00	8.77	76.73
B	15	3.54	6.98	7.78	81.70
B	16	0.02	0.16	0.41	99.41

second best scenario is represented by Call centre, providing Travel time, without any additional cost.

Furthermore, a conjoint analysis was carried on by module of SPSS® statistical software to compare the outcomes of the calibrated demand model. The results are described in Table 5. Higher utility values indicate greater preference. As expected, there is an inverse relationship between cost and utility, with higher costs corresponding to lower utility. Factors with greater utility range play a more significant role than with smaller range ones. Therefore, this table provides a measure of relative importance of each factor known as an importance score.

The results suggest that the respondents give more importance to the type of information (38.97%) and the cost (35.58%), and they are less interested in the system that

Table 5. Conjoint Analysis by SPSS software.

Attribute	Average importance	Level	Utility
Devices/Tech.	25.45%		
		Display at bus stop	0.3265
		Web-site	0.0075
		Sms	–0.1274
		Call centre	–0.2066
Info	38.97%		
		Waiting time	0.0611
		Travel time	–0.2654
		Route choice	0.2115
		General information	–0.0072
Cost	35.58%		
		Free of charge	0.8730
		Cost for each enquire	–0.4064
		Increase in ticket costs	–0.2177
		Monthly subscription	–0.2489
Constant	1.4957		
Pearson's R	0.968	Significance	0.0000
Kendall's tau	0.644	Significance	0.0003

provides the information (25.45%). The software also provides the part-worth for each factor level. These part-worth scores indicate the influence of each factor level on the respondent's preference for a particular combination. They are computed by the procedure through a set of regressions of the rankings on the profiles. Since they are all expressed in a common unit, the part-worth scores can be added together to give the total utility of a combination. The part-worth scores point out that the 'ideal' scenario of information could be represented by bus stop display, providing waiting time without any additional cost. The higher values of Pearson's R and Kendall's λ indicate that the model fits well with the data. The calibrated model confirms the outcomes of conjoint analysis through the simulation of probabilities of scenarios shown in Table 4.

The effect of rating the selected scenarios on the use of public transport pointed out that between 15% and 18% of the respondents along with bus stop display providing expected arrival time of the bus free of charge are willing to increase their use of public transport (Figures 1 and 2).

5. Analysis of uncertainty

We use Monte Carlo experiments to test under which conditions the ranking of probability in Equation (4) may change if parametric variations occur. The method involves specifying *a priori* distributions for two parameters of the model, which result not to be significant, specifically, they are the *constant* and the *device/technology*[1]. Sets of parameter values are drawn at random from the *a priori* distributions. To calculate the final sample size, we specified a 95% probability that the percentage changes in all four probabilities; this is estimated with a margin of error of not more than 0.1. The necessary sample sizes turn out

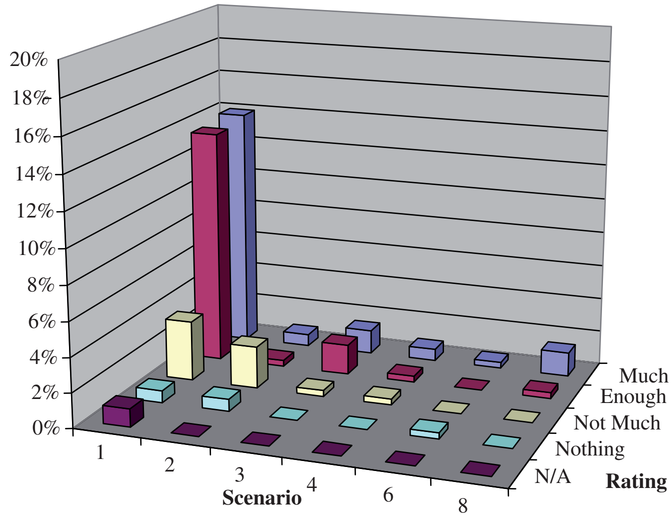

Figure 1. Rating of scenarios at the first place (questionnaire A).

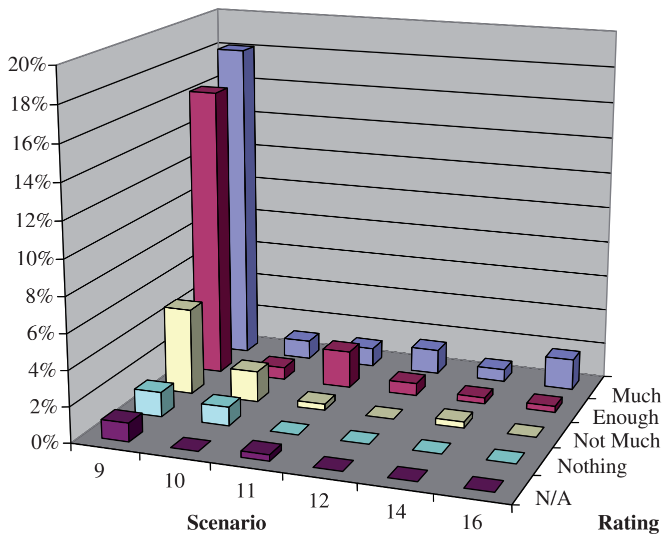

Figure 2. Rating of scenarios at the first place (questionnaire B).

to be 100. Furthermore, each parameter, w_i, is supposed to evolve according to the stochastic differential equation:

$$\mathrm{d}w_i = \mu w_i \,\mathrm{d}t + \sigma w_i \,\mathrm{d}z \quad \forall i. \tag{5}$$

This equation implies that w_i are changing according to a process of geometric Brownian motion (GBM). The term $\mu\,\mathrm{d}t$ is the mean or expected percentage change in w_i for the increment $\mathrm{d}t$, and μ is called the mean drift rate. The term $\sigma\,\mathrm{d}z$ introduces a random component to the drift, because $\mathrm{d}z = \varepsilon(t)\sqrt{\mathrm{d}t}$, where $\varepsilon(t)$ is a standard normally

Table 6. Monte Carlo simulation results for any scenario.

	Prob[$y = 1$]		Prob. [$y = 2$]		Prob. [$y = 3$]		Prob. [$y = 4$]	
Scenarios	Mean% change	SD	Mean% change	SD	Mean% change	SD	Mean% change	SD
1	1.059	29.963	−6.118	7.243	−7.731	37.126	1.814	5.240
2	7.785	49.700	−4.833	19.956	−9.514	11.056	0.985	9.796
3	14.911	65.702	4.451	41.453	−0.499	27.332	−0.479	5.109
4	27.524	91.487	14.017	63.346	6.928	47.561	−0.449	2.309
5	40.922	116.952	23.496	82.202	14.080	63.210	−0.350	1.360
6	13.802	62.423	−0.138	32.778	−6.039	16.624	−0.188	8.973
7	43.750	122.659	25.773	86.739	15.984	67.116	−0.300	1.118
8	29.632	95.844	15.721	66.992	8.338	50.834	−0.405	1.955
9	1.059	29.963	−6.118	7.243	−7.731	37.126	1.814	5.240
10	10.299	54.703	0.228	30.099	−4.081	15.695	−0.161	7.470
11	9.040	51.807	−1.990	25.224	−6.418	10.715	0.241	8.804
12	14.911	65.702	4.451	41.453	−0.499	27.332	−0.479	5.109
13	52.296	137.118	30.351	94.876	18.576	72.362	−0.390	1.343
14	10.407	54.856	−0.918	28.367	−5.624	13.399	0.005	8.491
15	11.622	57.707	1.271	33.091	−3.292	18.729	−0.298	7.001
16	66.816	165.869	41.877	116.904	28.177	90.758	−0.200	0.602

distributed random variable. A discrete approximation of (5) is given by the stochastic difference equation:

$$w_{i,t+1} = (1 + \mu)w_{i,t} + \sigma w_{i,t}\varepsilon_{t+1} \tag{6}$$

where ε_{t+1} are the standard normal variates and the implied increment is $\mathrm{d}t = 1$.

Table 6 reports the mean percentage change in each probability and the standard deviation across the 100 random samples per any scenario. Although the mean percentage change and the standard deviation are low only for Prob[$y = 4$], the results are robust to different combinations of the coefficients' values. This is because Prob[$y = 4$] has the highest value in all the scenarios. In fact, in the 100 experiments, Prob[$y = 4$] is higher than 90% in many scenarios.

6. Conclusions

A Stated Preference survey was conducted in Palermo. The study's main objectives were to investigate which combination of ATIS, real-time information provided and costs would influence the choices of citizens to use public transport. For this purpose an ordered probit model was calibrated and a conjoint analysis was carried out. The ordered probit demand model was calibrated to determine the potential additional share of demand attracted by the adoption of ATISs. Our analysis showed that cost and info were the most important variables. The best scenario is characterised by bus stop display, providing waiting time without any additional cost. Moreover the second best scenario is represented by Call centre, providing Travel time, without any additional cost. Furthermore, the signs of ordered probit model coefficients confirm that the employment of ATISs increase the probability of using transit and its perceived quality. The conjoint analysis results confirm the calibrated model ones through the simulation of probabilities of scenarios.

The combination of display at bus stop providing expected real-time information free of charge was preferred by the respondents and in particular 15% of them are willing to consider increasing their use of public transport if the previous scenario would be available in Palermo. Finally, a Monte Carlo simulation was carried out to appraise the uncertainty on some parameters of the calibrated demand model. The simulation highlighted as variations of parameters with low significance (constant and devices/technologies) do not produce significant effects on probabilities of scenarios. The calibrated model is robust to parametric variations.

The analysis did not highlight a real willingness to pay for higher quality real-time information systems since the scenario characterised by bus stop display, providing waiting time without any additional cost was preferred. It dominated all other scenarios. Nevertheless, the scenario choice probability decreases up to 5% for ticket additional cost of 20% or 30 cents/€ for single enquire.

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Note

1. Low significance of these variables may be due to the lack of information or knowledge on these variables by the respondents of the questionnaire. Thus, the results may be biased. Monte Carlo experiments allow one to test the robustness of the results if the values of these variables change.

References

AA.VV., 2006. ISTAT, *Annuario statistico* 2006, Roma.

Abdel-Aty, M.A., 2001. Using ordered probit modeling to study the effect of ATIS on transit ridership. *Transportation Research C*, 9, 265–277.

Abdel-Aty, M.A., Kitamura, R., and Jovanis, P., 1996. Investigating effect of Advanced Traveller Information on commuter tendency to use transit. *Transportation Research Record*, 1550, 65–72.

Amato, G., 2006. *L'influenza dei sistemi avanzati di informazione all'utenza sulla domanda di trasporto pubblico*. Thesis PhD. Department of Transportation Engineering, Palermo University, Palermo.

Chien, S.I.J., Daripally, S.K., and Kim, K., 2007. Development of a probabilistic model to optimize disseminated real-time bus arrival information for pre-trip passengers. *Journal of Advanced Transportation*, 41 (2), 195–215.

Chorus, C.G., *et al.*, 2007. Travelers' need for information in traffic and transit: results from a web survey. *Journal of Intelligent Transportation Systems*, 11 (2), 57–67.

Dziekan, K. and Kottenhoff, K., 2007. Dynamic at stop real-time information displays for public transport: effects on customers. *Transportation Research A*, 41, 489–501.

Grotenhuis, J.W., Wiegmans, W.B., and Rietveld, P., 2007. The desired quality of integrated multimodal travel information in public transport: customer needs for time and effort savings. *Transport Policy*, 14, 27–38.

Hickman, M.D. and Wilson, N.H.M., 1995. Passenger travel time and path choice implications of real-time transit information. *Transportation Research C*, 3, 211–226.

Khattak, A., Koppelman, F., and Schofer, J., 1992. Stated preference for investigating commuters' diversion propensity. A*nnual meeting of transportation research board*, Washington DC.

Kocur, G., Adler, T., Hyman, W., and Aunet, B., 1982. Guide to forecasting travel demand with direct utility assessment. Washington DC: United States Department of Transportation, Urban Mass Transportation Administration, Report UMTA-NH-11-0001-82-1.

Lappin, J., 2001. Understanding and predicting traveller response to information. A literature review, Washington DC: U.S. Department of Transportation, Federal Highway Administration, Office of Metropolitan Planning and Programs.

Lehtonen, M. and Kulmala, R., 2002. Benefits of pilot implementation of public transport signal priorities and real-time passenger information. *Transportation Research Record*, 1799, 18–25.

Luk, J.Y.K. and Yang, C., 2002. Impact of ITS measures on public transport: a case study. *Journal of Advanced Transportation*, 35 (3), 305–320.

Mishalani, R.G., McCord, M.R., and Lee, S., 2000. The value of real-time bus arrival information under various supply and demand characteristics, *ITS America 10th Annual Meeting*. Boston, MA.

Molin, E.J.E. and Timmermans, H.J.P., 2006. Traveler expectations and willingness to pay for web enabled public transport information services. *Transportation Research C*, 14, 57–67.

Nijkamp, P., Pepping, G., and Banister, D. eds., 1996. Public transport information systems: an English case study. *In*: *Telematics and transport behaviour*, Chapter 7. Springer, 137–157.

Ortúzar, J. de D. and Willumsen, L.G., 2001. *Modelling transport*. 3rd ed. Chichester: John Wiley & Sons.

Permain, D., *et al*., 1991. *Stated preference techniques. A guide to practice*. London: Steer Davies Gleave and Hauge Consulting Group.

Polak, J. and Jones, P., 1993. . The acquisition of pre-trip information: a stated preference approach. *Transportation*, 20, 179–198.

Polydoropoulou, A. and Ben-Akiva, M., 1998. The Effect of Advanced Traveller Information Systems (ATIS) on Travellers' Behaviour. *In*: R. Emmerink and P. Nijkamp, eds. *Behavioural and network impacts of driver information systems*. Aldershot, VT: Ashgate, 317–352.

Tan, M.C., *et al*., 2007. An algorithm for finding reasonable paths in transit networks. *Journal of Advanced Transportation*, 41 (3), 285–305.

Zavoina, R. and McKelvey, W., 1975. A statistical model for the analysis of ordinal level dependent variables. *Journal of Mathematical Sociology*, 4, 103–120.