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Users' preferences towards automated road public transport: results from European surveys

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Abstract

Collective automated road transport systems (ARTS) are the subject of current research in Europe. The paper reports on the results of the investigations about users' attitudes towards ARTS and conventional buses that have been carried out in twelve cities where the implementation of an ARTS service is being planned within the Citymobil2 project. A common stated preference questionnaire has been used. The econometric analysis has been based on the estimation of a logit model which has considered the choice for two alternatives: ARTS and minibus. The observed attributes are: waiting time, riding time and fare. Of particular interest, is the estimation of the alternative specific constant (ASC) of the ARTS, because this represents the mean of all the unobserved attributes of the automated system that affect the choice. With a common specification of the systematic utilities of ARTS and minibus, the observed attributes being the same, a positive value of the ASC is indicative of a relatively higher preference for the ARTS. The results show a relatively higher preference for ARTS across the cities where the ARTS is implemented inside a major facility. In other application contexts, commonalities in attitudes across cities are not found. The impacts on attitudes of the socio-economic attributes of the users are heterogeneous across cities.

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Keywords: automated road public transport; stated preferences; discrete choice; random utility; logit

1. Introduction

Automation in collective public transport has been a reality for several years by now in the case of guided systems with fully segregated right-of-way. Examples include automated metro and automated people movers in airports. Research has been undertaken in Europe in recent years with the aim of implementing fully automated road

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collective transport systems (ARTS – Automated Road Transport Systems). The key advantage of ARTS is identified in the potential for offering a higher frequency of service in the off-peaks, provided the operating costs are lower than a conventional bus. Also, there is a potential for higher flexibility in adapting the supply to demand because of the lack of drivers' scheduling constraints. In this latter respect, it is worth mentioning that the on-demand functionality of collective vehicles is limited by vehicle size constraints (Personal Rapid Transit, PRT, have not been the subject of the research reported on here).

The technology is available and a few demonstrations of ARTS have taken place. The key barriers to implementation are legal. The Rivium in Rotterdam is the only system currently operated on a permanent basis. The system serves routes in peripheral areas of the city, with collective automated vehicles running along a dedicated lane with priority at intersections (http://www.advancedtransit.org/advanced-transit/applications/rivium/). Demonstrations of ARTS on routes in mixed traffic, low-speed, environments are currently being planned within the Citymobil2 project of the Seventh Framework Programme of the European Commission (http://www.citymobil2.eu/en/).

The attitudes of the users towards ARTS, i.e. collective automated road transport systems, are still largely unexplored. Most of the studies for which literature is available investigated the potential demand for ARTS services on specific routes (Bekhor and Zvirin, 2004; CyberMove Consortium, 2004; NETMOBIL Consortium, 2005). Only a few studies have tackled the research objective of assessing the relative preferences of the users towards ARTS vis-à-vis a conventional bus. One took place in Leeds (Shires and Ibañez, 2008), one in Rome (Delle Site et al., 2011). Both were based on stated preference (SP) survey methodology (Louviere et al., 2000; Hensher et al., 2005), which is nowadays common practice in transportation planning and economic studies. Other studies have considered personal rapid transit (among these: Minderhoud and van Zuylen, 2005; Shires and Ibañez, 2008; Cirillo and Hetrakul, 2010; Cirillo and Xu, 2010).

The Citymobil2 project gave the opportunity to investigate the attitudes of the users towards automation in collective road transport in a variety of application contexts. Technical and non-technical feasibility studies concerning the implementation of a small scale ARTS service have been conducted in twelve cities across Europe. The cities have selected the route for the proposed demonstration. The routes include a range of applications: within city centre, within a major facility (such as a technology park or a university), from public transport node to a major facility, and from public transport node to a residential area.

The paper reports on the investigation which has been carried out with the potential users of the ARTS service that has been planned in each city. A common SP questionnaire across the twelve cities has been used, with the aim of investigating the relative preferences towards ARTS and conventional systems. Questionnaire responses have been analysed using logit models (Ben-Akiva and Lerman, 1985).

2. Methodology

2.1. Stated preference questionnaire and surveys

An SP questionnaire common across cities has been used. First, the route of the public transport service under planning is described. A brief description of two vehicle options, a conventional minibus and an ARTS, is provided. It is specified that the two vehicles are equal in terms of propulsion, and of total and seating capacity. Both will run in mixed traffic. The difference is the presence/absence of the driver. A picture of both is shown.

In the second part of the questionnaire, respondents are asked to choose between a minibus and an ARTS in different supply scenarios for a trip of a given length; the supply scenarios are defined according to different levels of the waiting time, riding time and fare of the minibus and the ARTS. The third part relates to the personal characteristics of the respondents: gender, age, income, education, occupation, car availability in the household, ownership of a public transport monthly ticket.

The attributes and corresponding levels of the SP design are in Table 1. The number of combinations in the full factorial design (8 combinations) has been reduced to 4 combinations using a within-alternative orthogonal design technique.

Samples are composed by potential users of the ARTS services under planning in each city. Data collection activities took place in Spring 2013. The majority of surveys used face-to-face interviews, in a minority of cases on-

line questionnaires have been used. In a few cities the level of the extra-fare was reduced to 1 EUR per return journey to take into account local conditions.

Table 1. Stated preference design – attributes and levels

Alternative	attribute	number of levels	levels
minibus/ARTS	waiting time	2	3/8 minutes
	riding time	2	5/10 minutes
	fare	2	as other public transport means in the city/extra-fare of 2 EUR per return journey

2.2. The econometric model

A binomial logit model is considered. We denote by 1 the minibus alternative, by 2 the ARTS alternative. The basic model has the following specifications of systematic utilities:

$$V_1 = \beta_1 \cdot WT + \beta_2 \cdot RT + \beta_3 \cdot FA$$
$$V_2 = \beta_1 \cdot WT + \beta_2 \cdot RT + \beta_3 \cdot FA + ASC \quad (1)$$

where WT is waiting time, RT is riding time, FA is fare, β_1, β_2, β_3 are the coefficients, ASC is the alternative specific constant of ARTS.

For fare, "effects coding" (-1/1) has been used instead of "dummy coding" (0/1) to eliminate confounding with the ASC: the code -1 represents the case where an extra-fare is paid; the code +1 represents the case where the same fare as other public transport is paid.

In the basic specification, the coefficients, which are representative of the marginal utilities of the attributes, are common to the two alternatives. A specification with alternative-specific coefficients has also been considered.

Other specifications include socio-economic variables of the users (gender, age, income, education, occupation, car availability in the household, ownership of a public transport monthly ticket) in the systematic utility of ARTS.

Of particular interest, is the estimation of the ASC of the ARTS, because this represents the mean of all the unobserved attributes that affect the choice: with a common specification of the systematic utilities of ARTS and minibus, the observed attributes being the same, a positive value of the ASC is indicative of a relatively higher preference for the ARTS than for the minibus, because of the resulting higher choice probability.

Also of interest, is the estimation of the effect on the ASC of the socio-economic attributes of the users, because this is indicative of the effect of the socio-economic attribute on the relative preference for ARTS (e.g. whether preference for ARTS increases with age or viceversa).

3. Application cases

According to the routes proposed for the ARTS demonstrations by the twelve cities, the following four application cases are included:

A1 - within city centre: La Rochelle (France), Oristano (Italy), Reggio Calabria (Italy), Trikala (Greece);

A2 - within major facility: CERN (Switzerland), Lausanne (Switzerland), San Sebastian (Spain), Sophia Antipolis (France);

A3 - from public transport node to major facility: Brussels (Belgium), León (Spain), Milan (Italy);

A4 - from public transport node to residential area: Vantaa (Finland).

The demonstrations that are planned to be actually implemented within the CityMobil2 project may be different from the scenarios of the SP questionnaire. In the planned demonstrations, segregated lanes or mixed traffic lanes will be used, the ARTS service will be free of charge. The infrastructure at stops will tend to be minimized because

the system will be operated on a non-permanent basis; no elevated platforms are required; vehicles will have unfolding ramps for wheelchairs.

3.1. Within City Centre

In La Rochelle the system links the railway station and the central park, with a length of 2.6 km. In Oristano the service connects the seafront of Torre Grande and the touristic port, with a length of about 6 km. In Reggio Calabria the Arts covers 4.2 km linking the Railway Central Station and the Executive Administrative Centre. In Trikala the system serves the areas of Varussi and Central Square, covering a length of 1.8 km.

3.2. Within major facility

In the CERN campus the system is thought to serve the main building area and the Restaurant #2, with a length of 2 km. In Lausanne the system is deployed in the EPFL campus where connects the north with the south area with length of 1.4 km. In San Sebastian the Arts runs inside the Miramón Technology park, linking the entrance of the park and the head offices of the different companies for a 2.1 km length. In Sophia Antipolis the system runs for 3.8 km linking the areas of Trois-Mulins and Saint-Philippe.

3.3. From public transport node to major facility

In Brussels the ARTS route is 2 km long and links the Saint-Luc Hospital with the Kraainem metro station. In León the system links the FEVE train station "La Asunción" and the University Campus, with an itinerary of 1.5 km. In Milan the system connects the "Molino – Dorino" metro station with the south gate of the EXPO 2015 (Milan Universal Exhibition).

3.4. From public transport node to residential area

In Vantaa the ARTS links the Kivistö railway station and its residential area with a length of 2 km.

4. Results

4.1. Econometric analysis

The results of the estimation of the model with the basic specification of the systematic utilities for the twelve samples are in Table 2. All the time and fare coefficients have the right sign. On the basis of the sign of the ASC, a relatively higher preference for ARTS is found in all cities of the application case "within major facility"; in three out of four of these cases the ASC of ARTS is statistically significant (null hypothesis of a zero coefficient, 10% significance level, two-tailed). In the other application cases, the relative preference is in some cities for the ARTS, in other for the minibus.

Estimation with specifications of the utility of ARTS including socio-economic characteristics of the users (not shown) have provided the following results. In ten cities out of the twelve the attribute "male" induces a relatively higher preference for the ARTS, while the attribute "female" induces a relatively lower preference for the ARTS. This occurs, with statistical significance (null hypothesis of a zero coefficient, 10% significance level, two-tailed), in all the four cities of the "within major facility" application case.

A commonality across cities in the sign of the effect on preferences of variables such as age, income, education, occupation, availability of car and ownership of public transport monthly ticket, is not found; the effects of these variables are heterogeneous across cities. In ten cities out of the twelve, the attribute "male" induces a relatively higher preference for the ARTS while the attribute "female" induces a relatively lower preference for the ARTS; this occurs, with statistical significance, in all the four cities of the "within major facility" application case. In three out of four cities of the "within city centre" application case, a higher education level induces a statistically significant relatively higher preference for ARTS.

The econometric analysis has also shown that alternative-specific coefficients for the time and cost attributes are not statistically significant, with the exception of the riding time in one city only (Brussels). This means that the marginal disutility of travel time (in particular, the travel time spent on-board) is found to be the same, irrespective of which of the two systems, ARTS or minibus, are used. In the case of Brussels only, the disutility of the travel time spent on-board the ARTS is found to be lower than the minibus.

Table 2. Model estimation in the twelve cases (basic specification – coefficient and t-statistic).

	A1				A2				A3			A4
variable	La Rochelle (FR)	Oristano (IT)	Reggio Calabria (IT)	Trikala (GR)	CERN (CH)	Lausanne (CH)	San Sebastian (ES)	Sophia Antipolis (FR)	Brussels (BE)	Leon (ES)	Milan (IT)	Vantaa (FI)
waiting time	-.0452	-.32052	-.1925	-.0960	-.38293	-.3778	-.2003	-.3131	-.2094	-.0372	-.23900	-.1562
	-1.11	-6.22	-3.58	-2.28	-13.24	-15.22	-4.39	-8.42	-4.92	-.53	-5.30	-2.18
riding time	-.0563	-.29100	-.2471	-.0872	-.34816	-.3976	-.2078	-.2807	-.1989	-.2414	-.19362	-.0067
	-1.95	-8.67	-6.89	3.02	-17.28	-23.18	-6.72	-10.75	-6.45	-4.83	-6.35	-.14
fare	.50548	1.56972	.78382	.46828	.99446	.55397	.83580	.73213	.49727	.35450	1.11167	.45181
	4.03	9.08	4.41	3.57	11.62	8.19	5.69	6.08	3.64	1.60	7.64	1.89
ASA (ARTS)	.56365	1.19353	-.4746	-.0136	1.22331	.86415	.28531	.16204	-.2753	-1.870	.86800	-1.568
	3.90	7.11	-2.65	-.09	12.14	10.07	1.85	1.24	-1.85	-7.48	5.69	-6.34
sample size	200	200	209	208	482	742	200	290	201	227	200	167

Key:
A1 = within city centre
A2 = within major facility
A3 = from public transport node to major facility
A4 = from public transport node to residential area

4.2. Comparison with previous studies

Shires and Ibañez (2008) and Delle Site et al. (2011) are relevant references because they have used the same methodology. i.e. logit models calibrated on SP data. The former has considered the relative preference between a conventional bus service and an ARTS in the context of an existing public transport line in Leeds (UK). The latter has considered the relative preference between a minibus and an ARTS for a short connection with a parking area in the new trade fair district in Rome (Italy).

Shires and Ibañez (2008) have found a relatively higher preference for the existing bus service compared with an ARTS, a result which, according to the authors, can be ascribed to an inbuilt bias towards the currently used transport mode. In the cities of the surveys reported on here new transport services (i.e. not currently existing) are considered, except the case of Reggio Calabria. Therefore, results are affected to a lower extent by the currently used mode bias, a circumstance that is confirmed by the relatively higher preference for the ARTS found in some of the "within city centre" cases (namely La Rochelle and Oristano). The Reggio Calabria case shows a statistically significant relatively higher preference for the minibus, a result which is similar to the one of Leeds.

Delle Site et al. (2011) have found a relatively higher preference for the ARTS in the case of the trade fair district. This result is similar to those found in the "within major facility" cases (namely CERN, Lausanne, San Sebastian, Sophia Antipolis), and in the case of Milan (connection between a metro station and the exhibition), which all show a relatively higher preference for the ARTS.

5. Conclusions

The surveys have portrayed, based on twelve cross-European samples, the attitudes towards automation in collective road transport systems. The samples relate to the potential users of ARTS for specific planned routes in a variety of application contexts in twelve different European cities. The results are representative of the attitudes of users who have been exposed to minimal information about ARTS, and who have had no experience of these innovative systems. Information and experience are, together with emotions, the key determinants of preference formation according to the standard behavioural choice model (McFadden, 2014). This is an important issue with implications for future research on the stability of attitudes with information and experience (the impact of experience on attitudes towards an electric and a conventional vehicle has been tackled recently; Jensen et al., 2013).

The cases investigated (except one city) relate to new services on routes where public transport is currently not existing. The results show that automation is, on average, not necessarily perceived as valuable, if the travel time and fare of the ARTS are the same as those of a conventional bus. A common trait of the results across the cases is the relatively higher preference for ARTS when this is implemented within a major facility. Common traits relating to the impacts on preferences of socio-economic characteristics of the users have not been found.

The econometric models that have been estimated are useful tools to obtain the shifts in preferences that would result from an increase of the relative frequency of the ARTS on that of a bus, or to compute the increase in the relative frequency of the ARTS that is needed to achieve a relatively higher preference. Also, they implicitly provide an assessment of the willingness-to-pay of the users for automation, since they can provide estimates of the shifts in preferences that would follow different fare policies.

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