Mode Choice of older and disabled people: A case study of shopping trips in London

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Abstract

This paper attempts to understand mode choice decisions among older and disabled people in London, with the objective of determining what policies can best meet their mobility and activity needs. A literature review is followed by a description of the data sets and modelling methods used in this analysis. Public transport accessibility measures are included and found to be associated with increased public transport use. Special attention is given to the marginal costs of car use. Model results are often very sensitive to different modelling assumptions on cost parameters. Through the analysis of several models it is shown that large investments (car, travelcards) are not amortized in the mode choice decisions made, but that marginal costs need to be appropriately specified. Other key results indicate that older people have a preference for independent mobility options and that the preference for taxis increases substantially with age.

Key words: Transport mode choice, disability, seniors, variable travel costs

1. Introduction

A growing issue for most western countries is the development of effective policies and options that will allow a rapidly increasing older population to maintain access to activities. The proportion of the population that is older is steadily increasing, leading to concerns about traffic safety as well as environmental impacts from their travel (Rosenbloom, 2001). An increasing proportion of older people are expected to continue to drive later in life than current older populations (e.g. Rosenbloom, 2001; Noble and Mitchell, 2001, Sweenly, 2004). While some fraction of older persons are physically capable of maintaining their mobility, others will suffer from disabilities that impair their ability to drive and to walk.

Older people in the UK make the majority of their trips by private automobile. Noble and Mitchell (2001) show statistics that even for those over 80 years of age, 70% of men in the UK drive for trips greater than one mile in length. These figures are likely to be lower in London where the public transport network is denser than in other areas of the UK, but large numbers, even in London, still drive vehicles. Many older people are also driven to activities by friends or family members. Rye and Scotney (2004) found that older people in Scotland are also increasingly driving cars rather than using public transport.

This paper seeks to analyze the choice of mode made by both older and disabled people (including the younger disabled) for shopping trips. We focus on shopping trips as previous work has found that most trips made by the population of older people fall into this category (Schmöcker et. al, 2005). Various subsidised transport services are provided in most countries to service these population groups. In particular, we analyze the options available within the jurisdiction of the Greater London Authority, consisting of 33 Boroughs and a total population of over seven million people of which 28.8% are older than 60 or disabled. These options include "Freedom Pass" cards for public transport and taxi subsidies (via Taxicards). In this paper we evaluate whether these schemes influence mode choice. In particular it is of interest whether these schemes also have an impact on the growing population of older car drivers. Understanding the costs of alternative modes and how these costs are perceived are also important in the mode choice decision. If marginal costs are of little importance then public transport might not be attractive even if provided for free.

Our focus here is on understanding mode choice decisions among older and disabled people. The objective is to help determine what policies can best meet their mobility and activity. In the following sections we first briefly review the existing literature on this issue. Then we describe the data and modelling methods used followed by a discussion of our results and the implications for policy.

2. Previous Literature

A variety of studies have examined the issue of mode choice among the older and/or disabled people. Many of these have focussed on just the choice between a subsection of the available modes, e.g. paratransit (dial-a-ride) services and traditional fixed-route transit services, or bus and private car, while a few have been more comprehensive. The literature in this area is not large and we focus on some of the more recent key studies.

One of the most comprehensive is the work of Stern (1993) who examined both mode choice and trip generation of older and disabled people in rural Virginia (Charlottesville and surrounding counties). While his focus was on measuring demand for public transit services (both traditional and paratransit), his mode choice model included a full choice set of driving cars, being driven, taxis, walking, and other community transport services. The model, based on a standard discrete choice multinomial logit model, used a variety of data sources including a choice-based sample.

Stern (1993) concluded from his analysis that the price of transit services did not have much effect on choice. This could be due to limited mobility options and income constraints among some segments of the population, as they found that the paratransit service was an important mode for many people, especially non-drivers. Not surprisingly traditional bus services were found to be unattractive to most people, especially those with walking difficulties. Buses that are accessible to disabled people did not have a large effect in increasing the desirability of the mode. Stern found that taxis are not highly regarded and speculates that this may be due to taxi drivers being unhelpful to older and disabled customers. These results are certainly informative about the importance of providing door-to-door dial-a-ride services, however the differences between a rural area and an urban area such as London make generalization difficult.

Noble and Mitchell (2001) analyze data collected from the British National Travel Survey 1996/98. Their work compares this data with previous NTS surveys which shows the change in mode choice towards private car in recent decades in the U.K. It is further shown that older people are less likely to give up driving as they age than in previous years. Older women remain more likely to use buses and travel as car passengers compared to males, but less so than in the past. Noble and Mitchell point out that this is because of the still significantly lower driving licence rate for women compared to men (65% compared to 22% for the over 70 year olds in the 1998-2000 survey) but the NTS data also suggest that this gender gap is also decreasing.

An important issue in studying the mobility of older and disabled people, is that they do not constitute a homogenous group. Hildebrand (2003) clearly showed how older people can be classified into different groups with consequences for both the activities they engage in and how they make trips. Likewise, disabilities can be quite varied with different impacts on mobility and the ability to access various modes of transport. It is, for example, important to distinguish between "younger" and "older" age groupings. Alsnih and Hensher (2003) suggest an age threshold of 75, which is when their health often starts to decline. They further point out that the needs and habits of older people are changing as they are staying mobile much longer than previously, confirming the U.K. trends with similar trends in Australia. This is reflected in their mode choice (driving until an older age), the kind of trips they make, and increased trip distances.

There have been some additional studies analyzing the mode choice of older people without specifically including mobility impairments in the mode choice estimation. The study by Schwanen *et. al* (2001) analyzes leisure trips of seniors. The authors note that this is an important but under-researched area not least because the number of these trips and their economic importance will grow in coming years. The focus of their paper is on the relationship between urban form and travel behaviour. They divide the Netherlands into districts and categorise them into six levels according to their urbanisation. As one might expect they find that the share of public transport is correlated with urbanisation. In the most urbanised areas older people use public transport around eight times more than in rural areas. A key finding of their study is that in rural areas public transport trips are primarily substituted by bicycles, which led them to conclude that a better public transport service does not get older people out of the car but rather away from the bicycle. The level of urbanisation affects primarily non-car users as car-users do not change their mode. Other results of their multi-nominal logit model confirm results found in other research (Noble and Mitchell, 2001; Alsnih and Hensher, 2003). The percent who drive alone slowly decreases with age and that for non-car owners, trips as a passenger increases with age. This suggests that older people in non-car owning households have a much greater reliance on trips with others.

Kim and Ulfarsson (2004) conducted a study in the U.S. based on data from Washington state. They show that lower income is associated with higher public transport usage, which is the opposite of what Schwanen *et. al* (2001) found in the Netherlands. Schwanen *et. al* suggested that this finding in the Netherlands might be associated with habit, that is, those who commuted by public transport when younger (and who generally had higher incomes) continue to use it when older.

Kim and Ulfarsson show that the distance (in terms of block number) between residence and nearest bus stop influences the mode share. Unfortunately walking trips are not included in their study to compare their results with the Dutch results. Nitta (1998) also points out that the nearest bus stop needs to be very close to the resident's home in order to be considered in an older person's choice set. With Japanese data Nitta (1998) estimates that bus stops need to be closer than a five minute walk. Further, Nitta estimates that interchanges between buses are a major disincentive and he estimates an equivalent time penalty of 20 minutes for each interchange.

Another area of research that allows one to gain insights into the mode choice of mobility-impaired people has focussed on the impact of providing dial-a-ride services to complement existing bus services. Wilds and Talley (1984) found that perceptions of the reliability of dial-a-ride were an important factor, as was total travel time between modes. Franklin and Niemeier (1998) examined the choice between traditional fixed-route service and demand responsive services using a choice-based survey method. The sample included disabled transit users over the age of 50. Contrary to the results of Stern (1993) they found fare levels to be a significant determinant in the choice of paratransit service. Surprisingly, older people were less likely to choose paratransit relative to conventional transit, although this may have been due to the sampling strategy employed that resulted in more able elderly people being surveyed on conventional transit with a sample of younger disabled people on paratransit.

Ben-Akiva et al. (1996) examined how improved scheduling systems may affect individual preferences for dial-a-ride services. They found that booking two hours in advance is preferred to 24-hour booking and to 15-minute prior booking, the latter perhaps being too short a notice for most people. They also found a strong preference for return trips arriving within 15-minutes relative to arriving within 30-minutes. While their sample was not restricted to older and disabled people, those with walking difficulties were found to be more likely to make fewer trips. Chen et al. (2004) also examine the effect of changes in waiting time, total travel time and cost for regular versus "ITS-enhanced" paratransit service amongst older and disabled people. They find that non-drivers and the disabled prefer the enhanced service, but that drivers do not have a measurable preference.

The analysis presented below focuses on some of these issues. Our models include various demographic factors, public transport service variables, and various policy variables that can be set by government agencies. The next section describes the mode choice options for older and disabled people in London. This is followed by a discussion of the data and analysis methods used in our study, followed by a presentation of results.

3. Mode Choice Options for Older and Disabled People in London

Older and disabled people in London have a wide variety of potential modes of travel. Figure 1 uses data from an interim release of the 2001 London Area Transport Survey (LATS), which was provided for this study. This figure shows the modal split by age (but not disability). LATS did not include detailed information on some transport options available to these groups (such as Dial-a-Ride services) but Figure 1 serves to show the variation in mode split between different age groups.

A large fraction of the elderly and disabled use their own cars or are driven by others to destinations. Bus services are widespread throughout the greater London region with a free pass (Freedom Pass) provided to those over the age of 60 and for the younger disabled. An increasing share of buses are fully wheelchair accessible, with all buses having low-floor access since 2005. Currently efforts to improve bus stop designs (in particular kerb-stone heights) to improve accessibility are being pursued (Transport for London, 2006). While rail and underground (tube) services are widely available, most are not readily accessible for wheelchair or electric scooter users. The key exceptions are the Docklands Light Railway and the Croydon Tramlink, which are wheelchair accessible.

A taxi subsidy scheme (Taxicard) is operated in each London Borough that provides an allowance of between 50 and up to an unlimited number of taxi trips per year to older and disabled people such that they pay only £1.50 per trip up to a preset maximum. Each Borough operates its own scheme with different criteria, including determining who is eligible for the scheme. These only apply to licensed Black Cabs as opposed to Minicabs. The difference between the two services is that Minicabs must be booked in advance, while Black Cabs can be hailed on the street or booked for pick up at home or other locations.. Minicabs tend to be substantially less expensive than Black Cabs. The data shown in Figure 1 clearly show that Taxi use clearly increases with age.

A relatively large fraction of trips are done by walking. Older people tend to have fewer total walking trips than younger people, however, as a proportion of all trips the share is larger (as shown in Figure 1).

Special Transport Services (STS) are also available. These include a Dial-a-Ride (DaR) service that operates throughout London and that provides about 1.4 millions trips annually (Transport for London, 2003). Users only pay between 60 pence and £3 per trip depending on the trip distance, with a discount available if the service is booked more than a day in advance. London's DaR scheme and the choice between advanced and immediate booking is described in more detail in Bell *et al* (2004). The National Health Service (NHS) operates transport services to bring people to their hospital appointment for non-urgent treatment. It is free but often criticized by users for being slow and unreliable (Bell *et al*, 2004). Other STS services are provided by a wide variety of community service organizations and pick up users for special purpose trips. LATS does not classify STS trips, although some of these may have been entered as "other" in the survey. Estimates suggest that only about 0.14% of all trips made by older and disabled people are provided by DaR services. Due to this data constraint and the still only marginal – though essential for some – nature of STS in London these trips are not considered in the analysis that follows.

4. Data and Methods

Mode choice data for single trips were obtained from the interim LATS data. In this survey, 67,252 individuals in 29,973 households were interviewed with samples spread all over London. The survey includes four main datasets for each individual: Household information, personal information, details on vehicles owned by the household, and, trip details of all trips done on one weekday. All interviews were done on a personal basis and the respondents were asked to fill in a one-day travel diary. In total, 176,453 trips were made by the individuals.

From the interim LATS dataset we extracted records for all persons aged 65 or older (8012 records) and persons younger than 65 "with a longstanding health problem that affects their ability to travel or get about" as asked in the LATS interview (2427 records), henceforth referred to as the "younger disabled". The total sample included 10,439 individuals.

Homebound trips are not included in the analysis. Analysis of the LATS data showed that 90.8% of homebound trips use the same mode as that chosen for the outgoing trip. Most trips made by this population group do not include linked trips to multiple destinations, but have only one destination. For those trips with just one destination 93.6% of the homebound trips use the same mode as they chose for their outbound trip. For those trips with more than two destinations, 82.9% use the same mode for the homebound trip. While this certainly demonstrates some added complexity in how individuals choose their modes, a detailed analysis of interactions between mode choice and trip chaining activity is beyond the scope of the current analysis. Our analysis focuses only on the mode choice for trips starting at home.

Of particular importance for this work is a classification of disability status in the sample. Specific details of the disability were extracted from the data. These included whether the respondent had difficulty walking, hearing, seeing, understanding directions and any other difficulties that impair mobility. Respondents were also asked whether they use a wheelchair. This information is particularly important as it allows us to understand whether certain types of disabilities influence the choice of travel mode.

The interim LATS version has information on public transport fares for the trips taken. Most older and disabled people, however, are Freedom Pass holders (2711 in the sample, or 84.1%) and thus travel for free. In fact all of the people in the sample should be eligible for a Freedom Pass; some may be unaware of the benefit or may forego it since they do not use public transport. There were 33 individuals in our sample who paid for a travelcard and 59 trips (by 48 users) where passengers paid for a single bus, rail or underground ticket. These might be individuals who use public transport at peak travel times (before 9:30am) when the Freedom Pass cannot be used.

In our analysis we assume the 2001 minimum fare levels for those who paid for a travelcard and as the fare for those who do not possess a Freedom Pass, in order to allocate costs to unchosen alternatives. This is a cost per trip of 70 pence for a bus trip and £2.00 for a tube or rail trip.

For taxi trips made with a Taxicard the fare is a flat fare of £1.50 in most London Boroughs with a maximum subsidy of £14.30 per trip. If the trip is longer the user has to pay the excess. For those trips made by users without a Taxicard we assume that the fare is £1.40 per km, which corresponds to information given on the 'Visit London' official website (Visit London, 2005).[1] Note, that this estimate includes several assumptions. Firstly, it is not known whether the user has actually used the Taxicard for a given trip. There is a limit on the number of trips that can be made with a Taxicard each year, in general between 72-168 trips per year, depending upon the policy of the London Borough that issued the Taxicard. Secondly, the LATS data did not specify with which taxi company the trip is taken. The fare for Minicabs is often significantly lower. Taxi fares are also a function of both distance and the time spent in traffic, the latter was not specified in the LATS data.

LATS includes information on both trip distance and journey travel time. Since LATS is based on actual trip data it does not include information on the unchosen alternatives. The travel time for the unchosen alternatives is estimated by linear regression using all trips made by older and disabled people. Differences in travel times between Inner and Outer London were also tested, but not found to be significant. These relationships are shown in Table 1. Note that the constant would

[1] Actual taxi fares can vary based upon whether one is picked up at home, at a taxi stand or by hailing and whether a Black cab or mini cab is used.

represent a fixed time for a given mode, which the equations, not surprisingly, show is largest for the public transport modes. We exclude the constant from the walking equation as there would be no fixed time component associated with walking. All these relationships imply reasonable relative waiting times and average travel speeds that would be expected of each mode, except for rail which is slower than would be expected.

The literature review highlighted that the neighbourhood and in particular public transport accessibility influence mode choice behaviour. We therefore derived a variety of spatial variables that represent the relative accessibility of the residence of each respondent. LATS includes the three digit postcode of each respondent's residence. From this we derived a dummy variable for whether the residence is in Inner or Outer London.[2]

Postcode specific information on public transport service quality was provided by Transport for London. This additional dataset was matched with the three-digit postcode in the LATS data, and allowed us to specify the number of tram stops, bus stop density (defined as bus stops per road length) and rail stop density (defined as rail stops per road length). We also created a variable, defined as "bus service accessibility" to assess the quality of the bus service from the respondent's home area. This variable measured bus service accessibility based on the number of all bus stops served directly from the routes within the given postcode. In London's bus network all bus stops can be reached if the passenger is willing to interchange, but Nitta's (1998) analysis showed that those bus stops that can be reached without an interchange are preferred by older people, and this variable provides a measure of the direct service offered from each postcode area.

The limitation of these variables for specifying relative accessibility is based on the rather large spatial area of three-digit postcodes, which can contain several thousand households. Therefore significant microscale local variability in accessibility is missed. Details such as whether the street must be crossed in order to reach a bus stop will influence accessibility as will the condition of foothpaths and sidewalks. We

[2] The total area of the metropolitan area is about 1580 sq km of which Inner London is about 320 sq km (20.2%) and Outer London is 1260 sq km (79.7%). Inner London is defined by Boroughs of Camden, Greenwich, Hackney, Hammersmith & Fulham, Islington, Kensington & Chelsea, Lambeth, Lewisham, Southwark, Tower Hamlets, Wandsworth, Westminster, and the City of London. Outer London tends to have more dispersed travel patterns typical of suburban areas.

also do not account for spatial autocorrelation between spatial units. That is, the accessibility of neighboring postcode areas may also influence choice.

For analysis of mode choice we use a simple multi-nominal logit (MNL) model expressed as,

$$P_n(i) = \frac{e^{V_{in}}}{\sum_{j \in C_n} e^{V_{jn}}} \quad (1)$$

Where P_n represents the probability of choosing mode i from the j possibilities in the choice set, C_n made by the individual n and V_{in} is the utility of choice i for person n. The derivation of the MNL model is described in Ben-Akiva and Lerman (1985). Note that the choice set and utility function might vary between individuals n. The utility function V is expressed by

$$V_{in} = x_{in}\beta_{in} + \varepsilon_{in} \quad (2)$$

where x_{in} is a vector of independent explanatory variables and vector β_{in} is to be estimated. It is assumed that the error terms are independently and identically distributed, which means that the utility of each option is independent from the utility of other options.

Clearly not all modes are in the choice set of each individual. It is possible to estimate mode choice models by including all modes within the choice set and in most cases those modes that are infeasible for an individual would have a low probability of being chosen. For this population group, which has many restrictions on the physical ability to travel, it is important to restrict the choice set used in the model to reflect actual options available.

The following assumptions were made to develop a constrained choice set for each individual. Older and disabled people are assumed not to use the bus for trip distances less than 300m. The underground is not used by wheelchair users and for trips of less than 500m[3]. Lack of a driving license or owning a car means that the choice of driving is not available. Those with difficulty seeing or understanding directions are also assumed not to have the choice of driving a car. Walk trips are not an option when distances exceed 5000m or 1000m for those with difficulty walking.

[3] These constraints were discussed with TfL staff familiar with many of the constraints that face the elderly and disabled.

After reducing incomplete observations our sample included 3222 individuals, 4286 trips and a total of 19348 observations associated with the choices available for each individual. Several models have been fitted and the following section presents results for selected models.

5. Results

The overall objective of our analysis is to understand what factors are associated with the choice of mode of older and disabled people. While both the physical condition of these individuals and their socioeconomic status may play a role, we are particularly interested in understanding what policies might be effective for providing greater mobility for those who are currently mobility constrained. In this study we focus on mode choice for shopping trips as these are the most frequent trips of seniors in London (Schmöcker *et al*, 2005). Individuals are assumed to have the choice of six modes of travel: car, tube/rail, bus/tram, taxicabs, car passenger, or walking. All models are estimated such that the car driver is the reference case, thus coefficients are interpreted relative to choosing to drive a car.

In analyzing the choice of mode, we have various hypotheses about the expected effect of the variables analyzed. In general, we expect travel time and fares to be disincentives. That is, those modes that result in lengthier travel times and/or higher costs will have a lower probability of use. We control for age and disability and in general expect increased age to be associated with use of modes that are dependent on others, such as being a passenger in a car or a taxi. Socioeconomic characteristics are also controlled for, including gender, income, and car availability. We also control for whether individuals hold a Taxicard. Information on Freedom Pass holders is used to estimate costs facing individuals, but holding a Freedom Pass is not an explicit control variable. We also control for the locational and accessibility variables described previously. We expect greater accessibility to increase the probability of the public transport modes being used.

One of the uncertainties in our analysis is the treatment of car travel costs. One would expect the decision to purchase and own a car to play an integral role in choice of mode and would not be exogenous to that decision. However, we do not have data on whether individuals own a car (only car availability in the household). Thus we can not estimate a full model but only a reduced form that ignores the decision to purchase a car. Given this, we can estimate car costs by an average value (which amortizes ownership costs per mile). However, this will not in general represent the marginal cost of travel, which may be more important for older people if the car was originally purchased when they were younger and had different travel needs. For this reason we also estimate models with a set marginal cost of petrol use plus parking charges (which can be significant) and then extend this to further assume that car passengers travel for free.

Model results are shown in Tables 2 – 4. In Table 2 we assume that cars costs average 90p per mile based on the British Automobile Association guideline for the full cost for a medium range car with annual mileage of 5000 miles (TheAA, 2005). The key result from this model is that the cost variable (fare) is positive and significant at the 90% confidence level. This does not match expectations but does suggest that individuals do not internalize depreciation and other costs associated with car use. Whether this is peculiar to the age groups analyzed here or would apply more generally is not known. However, it has often been argued that behavioural reactions to car use will more likely be affected by marginal cost considerations rather than sunk costs associated with owning a vehicle. Figure 2 shows that average car vintage increases with the person's age, suggesting that older people have cars with less resale value and thus have fully amortized the value of the vehicle in their choice of travel modes, thus setting costs based on marginal costs may provide better choice estimates

The travel time variable in Table 2 has the expected sign and direction and we find it is fairly robust across all the models tested. In Table 3 and Table 4 we find the value of time to be about £1.00 and £0.50 respectively. These seem to be reasonable values for discretionary (shopping) trips amongst a segment of the population that one would expect to value time less than those who are younger and working.

Table 3 assumes that car costs are marginal at 12p per mile plus associated parking costs. LATS contains data on the nature of parking for chosen trips. This includes the cost of parking, the type of parking (off street, multi-storey etc) and the type of ticket paid for parking. For trips without parking cost information, if information exists that the parking did not require payment or if the car trip did not involve parking, then the parking fee is assumed to be zero. Shopping trips to supermarkets often have free parking. For all the missing car trips and for the unchosen alternatives the charge for parking in both Inner London and Outer London is estimated at £3 and £1 respectively.

Results with marginal car costs provide a better model fit with expected signs on the cost coefficients, which is negative and significant. Our alternative specific constants suggest that choosing to drive is the preferred choice as all other constants are negative and statistically significant. Of these alternatives, the public transport modes and taxis are the least preferred, with car passenger and walking being preferred over these other modes. The alternative specific constants encapsulate unmeasured attributes associated with these modes, which could include various factors associated with scheduling or whether these modes access the desired destinations.

This last model assumes that car passengers receive free trips (as opposed to facing a portion of the costs as in the previous two models). The fare (cost) coefficient increases in value, as does the fit of the model as measured by the log-likelihood ratio. Interestingly, the car passenger alternative specific constant now indicates that this is the least preferred mode. Thus, this could indicate a preference for independence amongst the sample, as all else equal, public transport modes appear preferred over being captive to a friend or family member for a car trip.

Other variables in the models (we focus on Tables 3 and 4) provide some other interesting results. First, we see little difference in alternative specific coefficients associated with those aged 60-79. There is a slight dislike of rail and tube as a mode, but only at the 90% level of confidence. For those aged over 80 this becomes negative and significant relative to driving and the other modes. Taxicabs are the preferred mode for these individuals as we see a positive and significant coefficient value. This is the same for those individuals with a disability, a result strongly showing the importance of taxis to both older and disabled persons, a fact often not considered by transport planners.

A surprising result is the positive coefficient for those with walking difficulties associated with the choice of walking. The LATS analysis asked respondents about the "main transport mode" of their trip. This result might therefore rather suggest that those with walking difficulties avoid long trips by car where walking at the destination is required. This hypothesis is further supported by the shorter total trip distance of trips made by those with walking disabilities as found by Schmöcker *et al* (2005), but still may require further investigation. Wheelchair usage is clearly associated with less bus usage and less walking. The difference between wheelchair-users and those with walking disabilities might well highlight the fact that there are some very mobile wheelchair users. Surprisingly though, wheelchair usage is not associated with higher taxi usage.

The gender difference explained by Noble and Mitchell (2001) can also be found in this analysis with men being more likely to drive than women. The coefficient on car ownership also has the expected effect on car passenger usage. Finally, the results show that those with higher income are less likely to use public transport.

Those residing within Inner London are significantly more likely to use public transport, taxis and to walk, relative to both driving a car and being a car passenger compared to those living in Outer London (as shown in Tables 3 and 4). In Table 4, the sign flips for car passenger choice, suggesting this is less likely within Inner London.

The density of bus stops and stations in the person's home area is highly significant in all models with the expected sign. This confirms findings reported in Nitta (1998) that the distance to the bus stop is extremely important for older people. The "bus accessibility variable" which measures availability of direct bus service within an area is not statistically significant, raising the question whether a bus service serving a few major destinations is sufficient and additional bus services to more destinations do not encourage passengers to increase their bus use. This result may also suggest that proximate destinations and shorter journeys are more likely to be made by bus.

6. Conclusions

This paper analyzed mode choice decisions in London for older and disabled people using the London Area Travel Survey (LATS). Six mode choices were included, namely car (as driver), car passenger, bus/tram, rail/tube, taxi and walking. Choice sets were defined on the basis of personal and home location attributes.

One of our key conclusions was that the model specification was quite sensitive to the assumed costs associated with each mode, in particular for the choice of driving. Assumptions were made regarding the costs of unchosen alternatives (which is a requirement in all choice modelling with revealed preference data), we found the best model fit when marginal costs associated with car use are included, namely petrol and parking costs, rather than a full average cost associated with driving (which includes capital depreciation and maintenance costs). Whether this effect is more pronounced for older people is unknown, but they may be more sensitive to marginal costs as they may have less intention to resell their vehicles and recoup any remaining value. As older people tend to own their cars for longer periods, there is some supporting evidence for this hypothesis. Further improvements in model fit were achieved by assuming that car passengers and public transport travelcard holders assume no marginal costs associated with their trips.

Another interesting, but not unsurprising, result is that there appears to be a preference for modes that offer more independent mobility. In particular, the alternative specific coefficient for car passengers is generally negative, relative to driving and public transport modes. Taxi preference also appears to increase markedly with increased age and is also positive and significant for those with disabilities. This is an important consideration for policy makers, as taxis are an important mode for maintaining the mobility of older and disabled people, but they are also relatively costly. Understanding the benefits that this mode provides to older people deserves further research.

Another policy implication from these results is that it will be difficult to encourage a modal shift away from driving. There is a strong preference for car use among older people. In the coming years, when population ages, and in particular, the number of older people owning a car increases, this might cause further safety, congestion as well as environmental problems. This study only looked at shopping trips; Alsnih and Hensher (2002) found that there is an even greater car-dependency among older people for leisure trips.

Our analysis of spatial variables found that accessibility measures are highly associated with public transport use. Specifically, the higher the bus stop and rail density, the more older and disabled people choose public transport. Another accessibility measure tested in our models is the bus service accessibility, which relates to the number of destinations directly reachable from the person's home by bus. This was not found to be statistically significant. The shortcoming in our accessibility analysis was that the spatial unit, three digit postcode areas, is relatively large. This would tend to mask the detailed urban form characteristics that may make public transport accessibility difficult, such as sidewalk and street characteristics. These factors may be especially important for those with mobility difficulties.

Overall, these results provide a new perspective on the travel behaviour of older and disabled people. More detailed analysis of preferences and the specific attributes associated with each mode would be informative. Stated preference techniques are one way to gather this information. This was attempted in the early parts of this study, but there are unique difficulties associated with administering complex stated preference surveys to older people, which are a challenge for further research.

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Table 1 Regression relationships for travel times of unchosen alternatives

		coefficient	Std. Error	t-statistics	R2
Rail	Const	18.07	2.85	6.35	0.122
	Distance	5.46	0.86	6.33	
Bus	Const	19.60	0.70	28.09	0.073
	Distance	4.75	0.28	16.99	
Taxi	Const	11.77	1.40	8.39	0.108
	Distance	3.86	0.63	6.15	
Driving	Const	6.83	0.35	19.44	0.119
	Distance	3.54	0.15	24.14	
Passenger	Const	8.43	0.41	20.41	0.163
	Distance	3.48	0.16	21.21	
Walking	Distance	14.40	0.28	50.57	0.253

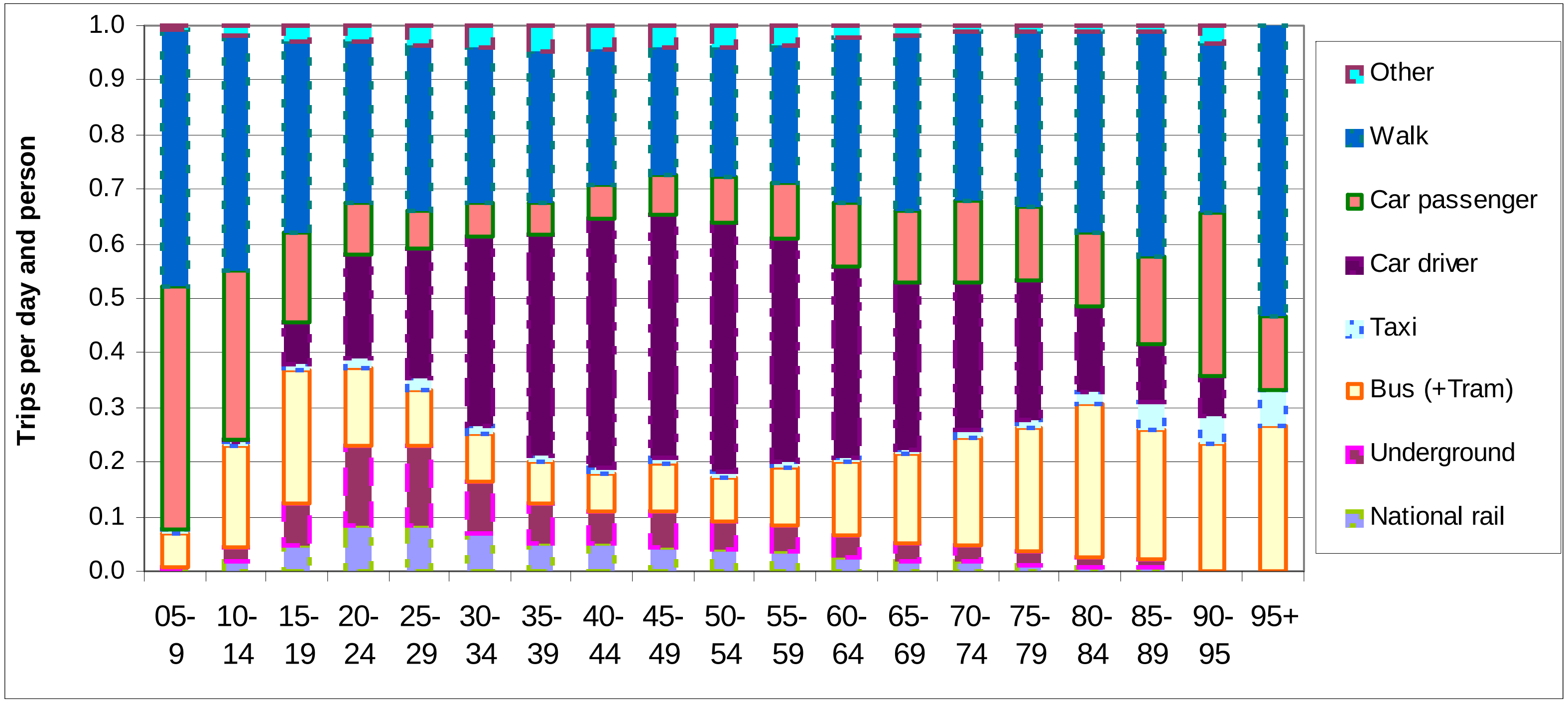

Figure 1 Modal Split by Age (based on interim LATS 2001)

Table 2 Mode choice model with car costs of 90p/mile

	Generic	Mode specific variables					
		Car driver	Tube, Rail / DLR	Bus / tram	Cabs	Car Passenger	Walking
Alternative specific constants		REFERENCE	**-1.367****	**-0.523***	**-7.108****	**-2.361****	0.059
Travel time							
Generic	**-0.024****						
Fare (Cost)							
Generic	**0.046***						
Age and disability							
60 – 79		REFERENCE	-0.367	**0.404***	0.858	0.349	0.287
80 plus		REFERENCE	**-1.263****	0.172	**2.216****	-0.016	-0.205
Disabled person		REFERENCE	**-1.429****	**-0.708****	**1.488****	0.039	**0.241***
Has walking disability		REFERENCE	X	X	X	X	**0.546****
Must use wheelchair		REFERENCE	X	**-1.450****	-1.838	-0.535	**-1.046****
Socioeconomic variables							
Gender (Male=1)		REFERENCE	**-0.861****	**-0.667****	**-1.401****	**-1.898****	**-0.288****
Car in household						**1.850****	
Income			**-0.023****		0.009	-0.007	-0.003
Travel Discounts							
Taxicard holder					**1.362***		
Location							
Inner/Outer London (Inner:0, Outer: 1)		REFERENCE	**1.195****	**1.142****	**1.820****	0.248	**1.026****
Accessibility variables							
Rail+tube+DLR stops per km of road length			**5.551****				
Bus stops per km of road length				**0.691****			
Bus service accessibility				-0.002			
Number of individuals	**3222**						
Number of trips	**4286**						
Number of observations	**19348**						
log-likelihood at convergence	-3593						
Number of parameters	46						
Log likelihood ratio index	0.426						

Table 3 Mode choice model with car costs of 12p/mile plus parking costs

	Generic	Mode specific variables					
		Car driver	Tube, Rail / DLR	Bus / tram	Cabs	Car Passenger	Walking
Alternative specific constants		REFERENCE	**-2.953****	**-2.133****	**-4.491****	**-1.997****	**-1.468****
Travel time							
Generic	**-0.029****						
Fare (Cost)							
Generic	**-1.719****						
Age and disability							
60 – 79		REFERENCE	**-0.567***	0.204	0.819	0.315	0.125
80 plus		REFERENCE	**-1.307****	0.110	**2.232****	0.024	-0.244
Disabled person		REFERENCE	**-1.338****	**-0.664****	**1.589****	0.059	0.192
Has walking disability		REFERENCE	X	X	X	X	**0.775****
Must use wheelchair		REFERENCE	X	**-1.588****	-1.848	-0.408	**-0.936****
Socioeconomic variables							
Gender (Male=1)		REFERENCE	-0.379	-0.213	**-1.012***	**-1.854****	0.138
Car in household						**1.563****	
Income			**-0.027****		0.007	-0.006	-0.003
Travel Discounts							
Taxicard holder					-0.267		
Location							
Inner/Outer London (Inner:0, Outer 1)		REFERENCE	**-1.681****	**-1.758****	**-1.246****	**0.453****	**-1.978****
Accessibility variables							
Rail+tube+DLR stops per km of road length			**5.187****				
Bus stops per km of road length				**0.774****			
Bus service accessibility				-0.002			
Number of individuals	**3222**						
Number of trips	**4286**						
Number of observations	**19348**						
log-likelihood at convergence	-3342.05						
Number of parameters	46						
Log likelihood ratio index	0.466						

Table 4 Mode choice model with car costs free for car passengers

	Generic	Mode specific variables					
		Car driver	Tube, Rail / DLR	Bus / tram	Cabs	Car Passenger	Walking
Alternative specific constants		REFERENCE	-3.719**	-2.898**	-2.570**	-4.977**	-2.358**
Travel time							
Generic	-0.026**						
Fare (Cost)							
Generic	-3.019**						
Age and disability							
60 – 79		REFERENCE	-0.628*	0.145	0.910	0.334	0.132
80 plus		REFERENCE	-1.278**	0.154	2.435**	0.212	-0.135
Disabled person		REFERENCE	-1.056**	-0.358*	1.939**	0.394*	0.210
Has walking disability		REFERENCE	X	X	X	X	1.047**
Must use wheelchair		REFERENCE	X	-0.918	-1.244	0.007	-0.645
Socioeconomic variables							
Gender (Male=1)		REFERENCE	-0.607**	-0.440**	-1.180**	-1.666**	-0.002
Car in household						1.927**	
Income			-0.026**		0.005	-0.010	-0.004
Travel Discounts							
Taxicard holder					-1.239		
Location							
Inner/Outer London (Inner:0, Outer 1)		REFERENCE	-2.947**	-3.026**	-2.469**	-3.927**	-3.235**
Accessibility variables							
Rail+tube+DLR stops per km of road length			4.853**				
Bus stops per km of road length				0.742**			
Bus service accessibility				-0.003			
Number of individuals	3222						
Number of trips	4286						
Number of observations	19348						
log-likelihood at convergence	-3088.33						
Number of parameters	46						
Log likelihood ratio index	0.507						

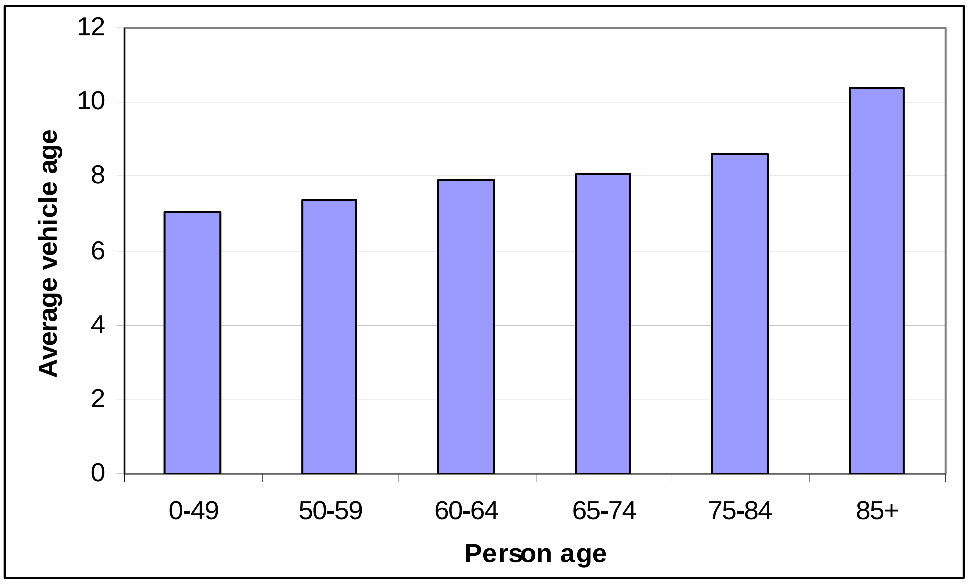

Figure 2 Average vehicle age by age (based on interim LATS 2001)