# A Ticket to Ride: Does Free Bus Travel Promote Active Ageing?*

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**Abstract**

In April 2006, the English government introduced a policy granting free local bus travel to all those over 60. The rationale was that by encouraging bus use, the reform could help to support active lifestyles, tackle social exclusion, and maintain well-being amongst the older population. Measures of this type, which attempt to reduce the costs of old age, are receiving increased attention as populations grow older. This paper considers both the effect of the reform on travel behaviour, and the potential benefits for older people themselves, their families, and the state. Responses are estimated using a difference-in-difference-in-difference approach, exploiting both age and geographic variation in eligibility. Results show an increase in bus use on the intensive and extensive margins of travel, invariant to individual socioeconomic characteristics. Additional journeys represent new trips, with little substitution across modes. Effects upon broader aspects of behaviour are concentrated amongst activities most closely related to bus travel, including walking and perceived access to services. There are no statistically significant effects upon social participation, or short-run measures of health. Taken together, results indicate that responses to the reform are consistent with encouraging "active ageing", but produced few spillovers upon outcomes not directly linked to transport.

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# 1 Introduction

In common with the rest of developed world, the population of England is ageing. Forecasts suggest that by 2033, 23 percent of the population will be over 65, compared to just 16 percent in 1984. Over the same period, the proportion under 16 is expected to fall from 21 to 18 percent (ONS, 2010). Whilst the rise in longevity is a testament to economic growth and advances in technology, it does not come without costs for individuals, their families and the state (Murphy & Topel, 2006). Declining physical and mental health, bereavement, and social detachment, all affect the quality of life of older people and place increased financial and time demands upon friends and family (Barnes et al., 2006; Lundberg & Pollak, 2007). The state faces larger pension liabilities, meets rising medical expenses, and provides care when families are unable to assist. In 2007/8, direct benefits for older people totalled £68 billion, compared to just £27 billion for families with children (Levell et al., 2009). This is in addition to income related benefits with disproportionate levels of older claimants, and the costs of providing medical and social care. Last year, the over 60s accounted for 44 percent of all hospital stays in England, up five percentage points in a decade (NHS, 2010).

Some costs associated with old age are inexorable consequences of the ageing process, or are fixed by the prior sequence of interactions between genes and the environment. Others are malleable, and can be shaped by the behaviour of older people themselves and those around them: regular exercise can, for example, help manage and even prevent chronic diseases such as diabetes, osteoporosis, cardiovascular disease and depression (Nelson et al., 2007; Chief Medical Officer, 2004; Oxley, 2009); levels of social detachment, exclusion, or isolation, are influenced by social and community infrastructures. The costs of chronic illness and social exclusion are substantial, for older people themselves, informal carers and the state (Goldman et al., 2006; Guralnik et al., 1996). Yet, despite the potential for significant fiscal and welfare gains, there are very few credible evaluations of the effectiveness of behavioural interventions, or the provision of behavioural incentives, amongst the older population (Dora, 1999; Findlay, 2003; Windle et al., 2008).

This paper examines behavioural responses and potential benefits associated with a specific reform that provides travel incentives to the over 60s in England. The reform in question, henceforth known as the Free Bus Pass (FBP) policy, is a rise in the minimum rate of bus fare concessions for older people from 50 percent to 100 percent, introduced in April 2006. The FBP policy is strongly endorsed by charities and support groups, and has proved very popular, with a 75 percent take-up rate by 2008/9. Total fiscal costs of all concessions now stand at £1 billion per year, or £87 per person over 60. Accessible and affordable public transport is a key component of what the WHO term active ageing: "the process of optimizing opportunities for health, participation and security in order to enhance quality of life as people age" (WHO, 2002)[1]. The particular importance of public transport provision lies in its capacity to support active lifestyles and levels of physical activity, facilitate access to services, and encourage social interaction and participation[2].

The principal contribution of the paper is to provide direct empirical evidence for how a behavioural intervention can affect the behaviour, lifestyles, and health of older people. As the population ages, the question of how to contain the fiscal and welfare costs of old age is set to become increasingly important for both the public and health economics literatures, and for policy makers. The second, and more policy-focused, contribution is to assess whether changes in public transport use do deliver the benefits hypothesised by the active ageing agenda.

Individuals are treated by the FBP policy if the reform changes their eligibility for free travel. Approximately 12 percent of (360) local authorities (LAs), and 20 percent of the population, already had free travel schemes prior to 2006. These schemes covered LAs in London, the West Midlands conurbation, and Merseyside, which are all disproportionately urban. The treated group is thus comprised of individuals aged over 60, living in areas without pre-existing free travel policies. The two sources of variation in treatment status give rise to two possible controls groups: first, those aged under 60, living in the same local authorities; and, second, those over 60 living in areas with pre-existing schemes. There are significant differences between the observable characteristics of the treatment group and both sets of controls. Policy effects are therefore estimated within a difference-in-difference-in-difference (DDD) framework, using pre- and post-reform data on travel, and conditioning on a range of individual, household and local authority level characteristics. The common trends assumptions underlying this approach are considered in a series of robustness tests.

Data on travel behaviour are provided by the National Travel Survey (NTS), from 2004 to 2008. The sample includes all respondents in England aged 45 and over, a total of 34,321 individuals. The NTS has two components: an interview, providing social, economic and

[1]As part of this policy approach, the WHO launched the Global Age-Friendly Cities Network in July 2010, with the objectives of making cities better suited to the needs of older people and creating a network to share best practice (WHO, 2007). The OECD uses a related concept of "healthy ageing", which focuses more directly upon health (Oxley, 2009).

[2]The government in England only states objectives briefly and ex-post, with the 2006 Budget Report stating that the reform "recognis(es) the importance of public transport for older people and the role access to transport has to play in tackling social exclusion and maintaining well being" (HM Treasury, 2006, para 5.50). The Scottish Executive, who introduced precisely the same reform in 2002, were more explicit with objectives including "improved health by promoting a more active life-style" and "improved access to services, facilities and social networks, and so improve social inclusion." (Rehfisch, 2009, p. 4). In recognition of the importance of public transport to older people, and their relative physical and economic disadvantage, discounted fares are widespread across both Europe and North America, including Paris, Barcelona, New York, and Boston.

demographic information at the individual and household level; and, a seven day travel diary. The data are augmented by fixed and time-varying area characteristics at the local authority level.

More explicit measures on the benefits of public transport, as highlighted by the WHO, come from the Active People Survey (APS) and English Longitudinal Study of Ageing (ELSA). The APS is a repeated cross-sectional survey, which provides a record of walking behaviour and participation in an exhaustive list of sporting activities. Wave one ran from October 2005 to October 2006; wave two took place between October 2007 to October 2008. The sample includes 155,117 individuals, aged 45 and over. ELSA is a cohort study that follows a panel of over 50s in England, which currently comprises four waves: 2002, 2004, 2006 and 2008. Each wave contains detailed information on individual health, wealth, work, activities in retirement, expectations, and perceptions. The baseline sample includes the 6,200 individuals who are present in all four waves. The main results are as follows.

First, the FBP reform increased pass ownership and bus use on all possible margins. Pass ownership increased linearly over the first two years of the reform, with an average rise across the period of 15 percentage points. The average marginal rise in weekly bus journeys was 0.33, from a pre-reform baseline of 1. At the extensive margin, the probability of making at least one journey in the travel diary week rose by 4.9 percentage points; at the intensive margin, the average number of journeys per week conditional upon use, rose by 0.34. These magnitudes are approximately equal to moving from the third to first (bottom) income quintile, and are in line with elasticities for local bus travel typically estimated by the transport literature (Balcombe et al., 2004). Average marginal effects on both pass ownership and bus travel are larger in year two (April 2007-March 2008) than year one (April 2006-March 2007), but the differences are not statistically significant. Data from the last eight months of 2008 indicates that lifting of geographical restrictions provided no additional boost to pass ownership or bus use.

Second, travel responses are greater in areas with a medium to high population density, but do not vary by individual characteristics: there is no consistent evidence of statistically significant heterogeneity by age, although responses are typically larger those aged 65 to 74; and, reform effects do not differ by socioeconomic and demographic characteristics characteristics, including income, socioeconomic group, sex, and household composition. The impacts of the reform are therefore not confined to traditionally disadvantaged groups.

Third, there is no strong pattern of substitutions across modes, with no significant change in recorded journeys made by car, car passenger, rail, or on foot. The effect of the reform upon total journeys is positive but not statistically significant.

Fourth, results from APS and ELSA indicate that benefits from the reform are derived from sources most closely related to travel. APS data show that reported days of moderate walking increased by an average of 0.5 days per month, an effect consistent with the growth in bus use. Results from ELSA indicate 14 to 20 percentage point rises in the probability of reporting very easy access to vital services, amongst those who used buses in 2004.

Fifth, there is no evidence of substantive spillovers upon sporting activity, social participation or self-reported well-being. The reform does carry benefits for older people, but they are limited in scope and should not be overplayed. Our results suggest that cross-sectional correlations between health, lifestyles, and activities such as bus travel are in part driven by unobservable factors, which must be accounted for when identifying causal relationships.

Sixth, tentative welfare calculations suggest that the reform did generate a net welfare gain to society. However, a large proportion of that gain is attributable to the funding formula, rather than external benefits associated with active ageing.

The structure of the paper is as follows. Section 2 discusses the relationship between travel and active ageing, and describes the reform. Section 3 presents a simplified model of travel demand, which assesses how the reform might change travel behaviour. Section 4 details the travel data and the econometric approach. Section 5 presents the baseline results for changes in travel behaviour and robustness tests. Section 6 presents Active People and ELSA results. Section 7 provides very approximate welfare calculations. Section 8 discusses the implications of the results. Further results and robustness tests are detailed in the appendix.

# 2 Background

## 2.1 Travel and Active Ageing

The economic justification for providing bus travel incentives for the older population rests upon the assumption that pre-reform levels of travel were too low. Suboptimal demand for buses could arise through incomplete information as to the current and future benefits of travel and associated activities, or through external gains to family, carers, fellow travellers, the community, and the state, which are not internalised[3]. In the presence of such market failures, a standard second best solution is to use taxes or subsidies to realign incentives. Just as taxes are frequently applied to “unhealthy” goods, such as cigarettes and alcohol, the FBP policy subsidises bus travel to bring net benefits observed by individuals into line with the

[3]For the state, near complete insurance against health expenditure creates the potential for ex ante moral hazard, reducing consumer demand for self-protection or preventative health activities. However, in reality, patients are only insured for the financial costs of their treatment and not the utility loss. Moreover, the cure is often incomplete. The extent of moral hazard is therefore almost certainly small. (Kenkel, 2000)

true, and supposedly higher, net gains to that individual and to society (Arnott & Stiglitz, 1986). Credit constraints or poverty cannot be the primary motivation, as a targeted lump sum transfer would be far more efficient than a universal fare subsidy. (Kenkel, 2000)

Bus travel is principally of instrumental rather than intrinsic value. The bulk of any benefits from the reform should therefore operate through activities associated with bus journeys, rather the trips themselves. The three channels considered here are those highlighted by the WHO: supporting an active life-style and levels of physical activity, facilitating access to services, and, encouraging social interaction and participation.

A rise in bus use could increase physical activity through the process of making the journey, or through activities undertaken at the destination. Physical activity has an important role to play in the prevention and treatment of a wide range of chronic diseases and conditions, including cardiovascular disease, osteoporosis, diabetes, hypertension, anxiety and depression. In both the US and UK, the official recommendations are that older adults should undertake at least 30 minutes of moderate exercise, five days of the week (Nelson et al., 2007; Chief Medical Officer, 2004). However, there are substantive health benefits, even from small or modest increases in activity. (Nelson et al., 2007; Dora, 1999; Oxley, 2009)

Public transport use tends to encourage physical activity, with users walking further and more often than non-users[4]. A 2005 UK time use survey indicates that two-thirds of those recording any active transport (walking or cycling) meet the recommended physical activity levels through active transport alone (Adams, 2010). Available evidence therefore suggests that the reform could boost physical activity levels, and that any increases could have health and welfare benefits for older people, which, in turn, carry potential cost savings for the state and informal carers (Goldman et al., 2006; Guralnik et al., 1996). Levels of physical activity may be too low through imperfect knowledge of the current or future benefits for themselves, or the failure to account for the medical costs borne by others. (Nelson et al., 2007; Chief Medical Officer, 2004; Murtagh et al., 2010)

Vital services for older people include shops, post offices, medical care, and social clubs. Even where service access might be considered a priority, the usage and expenditure of older people can be price sensitive[5]. The direct benefits of improved access include increased use and a reduction in the burden on friends and relatives to provide transport. Indirect benefits stem from the option value of access: control and autonomy are two elements considered

[4] Pre-reform data from the NTS (Jan 2002- April 2006) suggests that amongst the treatment group (aged 60+ in Treatment LAs) walking journeys were 36 percent higher, and short walks 89 percent higher, for bus users (those recording at least one bus journey during the travel diary week), relative to non-users. This pattern is replicated using a variety of data sources (Murtagh et al., 2010).

[5] For example, in a recent paper on a retirement health insurance plan in California, Chandra et al. (2010) examine the effects of increased co-payments on health care utilisation. They find that a rise in co-payments for a visit to a physician from $0 to $10 resulted in a 17.5 percent decline in office visits.

critical components of quality of life (Barnes et al., 2006), whilst surveys of older people point to the importance of being able to "get around", rather than any particular type of journey (Titheridge et al., 2009).

The last channel considered is the impact of increased bus travel on social interaction and participation. The most direct benefits occur when additional journeys are made to visit friends and relations or to participate in social activities. However, the use of public transport can, in itself, increase the interactions older people have with neighbours, fellow bus travellers, and the local community. Increasing levels of social interaction has important and multifarious benefits, including enhanced access to information, networks of market and non-market assistance and support, mental stimulation, and physical activity (Glaeser et al., 2002; Barnes et al., 2006). On this dimension in particular, older people may not internalise the benefits that their social interactions have for their peers, families, or state services[6].

The discussion thus far has presumed that an improvement in the health and welfare of older people will reduce fiscal costs. However, any resulting increase in life expectancy could counteract these savings as medical and social care are spread out over longer periods. Whilst there is certainly the potential for offsetting costs, existing estimates of the net cost of a sedentary lifestyle suggest that the net effect should be to reduce the fiscal burden (e.g, Manning et al., 1991)[7].

## 2.2 The Free Bus Pass (FBP) Policy

Bus travel is the most frequently used mode of public transport in England. In 2003/4 official estimates put total number of bus journeys at four billion, or 81 journeys per person per year. Usage is highest amongst teenagers and retirees, when car access is relatively low. For those over 60, living in households without a car, buses are the main means of transportation[8].

Local bus services have been operated by private companies since 1985. Concessionary travel for older people is provided by local (government) authorities (LAs)[9]. This paper considers a reform, introduced in April 2006, which increased the statutory minimum rate

[6] See Oxley (2009) for a survey of policies that might promote "healthy ageing" through increasing physical exercise, improving health care service access, and building social capital.

[7] Manning et al. (1991) estimate that a sedentary lifestyle imposes $1,650 of external costs (1986 dollars) through increased demand for medical care; this is partially counteracted by less time spent in nursing homes, but the net effect is still strongly negative. As most of the potential benefits of increased bus travel discussed in this section should not lead to substantive increases in life expectancy, any countervailing costs should be small.

[8] Average bus journeys calculated using (Department for Transport, 2009). Information on pensioner households are author's calculations using the NTS

[9] There are 360 local authorities in England, populations vary from 7,200 in the City of London to almost 1 million in Birmingham. The median population is approximately 150,000.

of concession from 50 percent to 100 percent (the FBP policy)[10]. Under the new regime, all people aged 60 and over were entitled to apply for a (free) concessionary pass from their LA, providing free travel, at off-peak times, within their LA of residence. On the first of April 2008, geographical restrictions were lifted, with the new passes entitling holders to free travel nationwide[11]. Baseline NTS travel specifications consider only the 2006 reform, but extensions examine the first eight months of the 2008 reform. APS data covers only the pre April 2008 period, but ELSA results will not distinguish between the two reforms.

A minority of LAs, including all those in London, Merseyside and West Midlands, operated free travel schemes that pre-dated the FBP policy reform. These LAs are high population density urban areas, and therefore not representative of England as a whole. In 2003, free schemes operated in 12 percent of local authorities, covering 22 percent of the English population. Concessionary travel arrangements in such areas were largely unaffected by the reform[12]. A local area is defined as a "Treatment LA" if it did not operate a free travel scheme prior to 2006 and a "Control LA" if it did.

Bus operators are compensated for the concessionary scheme by LAs on the basis of "no better off, no worse off". The reimbursement package covers lost revenues from journeys that would have been made at full fare, the costs of administering and implementing the concession, the marginal cost of additional journeys, and forgone revenues from displaced paying passengers (Oxera Consulting, 2009). Funding is provided to LAs from central government. From 2003/4 to 2005/6, total annual concessionary fare reimbursements stood at a little below £200 million in Treatment LAs and at around £335 million in Control LAs (current prices). In the post-reform year of 2006/7, expenditure in Treatment LAs more than doubled to £417 million, whilst the concurrent rise in Control LAs was just ten percent. In 2008/9, the later national reform prompted a further 20 percent rise in Treatment LAs, compared to four percent in Control areas[13].

[10]Prior to 2001, 97 percent of local authorities (LAs) in England operated a concessionary scheme for older people, funded by local tax payers; the most common form was a half fare reduction. The first statutory minimum standard was introduced in April 2001, under the Transport Act of 2000, with all men over 65 and women over 60 became entitled to a (free) pass from their LA, providing off-peak travel at half the adult rate. The age of eligibility equalised to 60 two years later. For a majority of passholders, the reform had minimal effects on fares, as their LA already offered a scheme at least as generous as the statutory minimum.

[11]Over the next decade, the age of eligibility will track the staggered increase in the state pension age for women, from 60 to 65.

[12]West Midlands PTE provided free travel for those over 65, and half price travel for those 60-64. Concessions in all other areas begun at 60. Another group of local authorities offered hybrid schemes, providing fixed fares. However, it is unclear how different these polices were from the minimum standard, as bus companies will not provide a fare time series by LA. The West Midlands change will be addressed by the estimation strategy. The presence of hybrid schemes is ignored.

[13]The approximate annual cost of the current scheme is £62 for every person over 60 in a Treatment LA, and increase from £22 in 2003/4 (current prices). The cost in Control LAs is much higher, at an average of £200 per person over 60, due to higher underlying levels of bus use and enhancements above the

Payments to bus companies represent transfers from the government to pre-existing bus users, equal to the number of pre-existing journeys multiplied by the difference between pre- and post-reform fares. As pre-existing users are disproportionately disadvantaged (and urban), the implied distribution of resource transfers is far more progressive than is typical for universal benefits[14]. Any additional journeys generated, either from pre-existing or new bus users, carry a very low fiscal burden as bus operators are reimbursed at marginal cost at £0.01 to £0.15 per journey(Department for Transport, 2010). Prior to the reform, the unconditional average value of journeys (adult bus fare × bus journeys) made by those aged over 60 in Treatment LAs was approximately £66 per year. For bus users, the average is much higher, at £310, somewhat more than the annual Winter Fuel Payment (£200 for those 60-79, £300 for those 80+). Given the 50 percent concession rate that operated until 2006, expenditure is approximately half these journey values.

### 2.3 Definition of Treatment

An individual is treated by the FBP policy, if the reform changes their entitlement to free travel. Treatment status thus varies by both age and geography, as described in Table 1.

The treated group comprises of individuals aged 60 and over, living in Treatment LAs. The remaining three quadrants represent possible control groups. The "age controls" include those in the same areas, but aged under 60 and therefore ineligible for the concession (bottom-left). The "geographic control" group contains individuals aged 60 and over, who qualified for free travel prior to the reform (top-right). The remaining group, those aged under 60 and living in Control LAs, are ineligible on age grounds. As treatment is not contingent upon pass take-up or use, all results will estimate intent to treat (ITT) effects.

## 3 The FBP Reform and Changes in Travel Behaviour

To clarify the mechanisms through which the FBP could alter travel behaviour, we consider a simplified model of travel demand[15]. Individual $i$ has T units of time per week. For each time-unit, $t$, $i$ generates utility, $u_{ita}$, from choosing amongst the $a = 1......A$ time use alternatives, or "activities". These $A$ alternatives are comprised of one option of home consumption ($HC$), and multiple activities outside the home ($\mathbf{OC}$), each of which is defined

statutory minimum. Author's calculations using RO2 Highways Road and Transport Outturn (Department of Communities and Local Government) - and annual population estimates.

[14]Between April 2003 and March 2006, for instance, the average annual value of bus journeys made by older people in Treatment LAs was £83 for those in the bottom income quintile, compared to just £29 in the top quintile. Author's calculations using the National Travel Survey.

[15]The model is provided in full in Appendix A

by a mode/destination combination. The price of $HC$ is normalised to 1, with $p_{at} > 1$, when $a \neq HC$. Income not spent on activities is consumed as a composite commodity of all other goods.

Weekly utility is assumed to be additively separable across journeys, and linear in all arguments, such that each activity decision may be treated separately. The indirect utility of activity $a$, for individual $i$, in time $t$, is therefore equal to the following (Nevo, 2000):

$$v_{ita} = \alpha_i(y_i - p_{at}) + Act'_{ita}\mu_{it} + \varepsilon_{ita} \tag{1}$$

where $\alpha_i$ is an individual specific scalar, which represents the consumers marginal utility of income; $y_i$ is income; $Act_{ita}$ is a vector of observed characteristics pertaining to the alternative and the decision maker; and, $\mu_{it}$ a vector of individual specific taste parameters. For any given $t$, activity $a$ is chosen if $v_{ia} = max(v_{i1} \ldots v_{iA})$. (Train, 2003)

The FBP policy affects travel behaviour by altering the indirect utility of all activities that incorporate buses, $v_{ib'}$ (where $b'$ is the subset of activities that use bus travel). The reform can operate through three channels: $p_{b'}$, $Act_{ib'}$, and $\mu_i$. In line with standard price theory, a reduction in $p_{b'}$ will unambiguously increase $v_{ib'}$[16]. However, there may also be indirect effects upon the characteristics of bus travel $Act_{ib'}$, such as the need to carry correct change, or upon tastes for characteristics, $\mu_i$, through government advertising, peer effects or an entitlement effect. In theory, the changes in $Act_{ib'}$, and $\mu_i$ could have a positive or negative effect upon $v_{ib'}$. In reality, there are few downside risks; the effect of the reform upon $Act_{b'}\mu_i$ is therefore assumed positive[17].

## 3.1 Travel Responses

The model generates the following very standard predictions for the changes in travel behaviour following the introduction of the FBP policy.

1. A rise in the total number of bus journeys: the rise in $v_{ib'}$ increases the probability that the chosen activity will involve bus travel, thus (weakly) increasing the total number of bus journeys made across T.

[16] The specification for indirect utility implies that income effects are small, which will be reasonable for all but the poorest individuals as the bus fare share of expenditure is very low. Alternatively, (1) could be viewed as a linear approximation to the true indirect utility function and income effects for the vast majority will be small. Hence, for demand to fall income effects would have to be negative and substitution effects would need to be close to zero.

[17] The demand for bus travel could fall if there is an increase in overcrowding, which reduces the comfort of bus travel, or the ability to get on to a service. However, bus services at off-peak times have high levels of spare capacity, and passenger surveys indicate no substantive changes in the levels of overcrowding (Integrated Transport Planning Ltd, 2009).

2. A (weak) rise in the total number of journeys: the rise in $v_{ib'}$ increases the indirect utility of **OC**, relative to $HC$, reducing the probability that home consumption is chosen.

3. A substitution of journeys across modes and destinations: activities that use other modes are replaced by activities that use bus travel, due to the relative rise in $v_{ib'}$. The response of $v_{ib'}$ to the reform could vary across destinations, changing the relative probability that each destination will be chosen.

4. Heterogeneity across individuals: the response to the reform will vary across individuals, through $\alpha_i$,$y_i$, $Act_{ita}$, or $\mu_i$.

5. The reform unambiguously increases the utility of pre-existing bus users, who gain at least a transfer equal to the value of their pre-existing journeys. It is assumed this transfer increases the consumption of $z$. All others gain only if behaviour changes[18].

## 3.2 Potential Benefits of Travel

As described in section 2.1, the implicit assumption underlying the reform is that pre-reform levels of bus use were too low. In the context of the model, this would occur if the private benefits associated with travel, $v_{ita}$, are lower than the associated social benefits, $s_{ita}$. Bus travel is assumed to carry external benefits through its role in promoting physical activity, services access, and social participation. However, each of these channels requires that responses to the FBP Policy take particular forms. An increase in levels of physical activity implies that additional bus journeys are not substitutions from more active modes, such as walking. Both improved access to services and enhanced social participation stress require that journeys are made to certain destinations, and are additional journeys, rather than substitutions across modes.

For each potential benefit discussed, the gains from the policy depend not just on how travel behaviour responds, but who responds. If the effects of the policy are concentrated amongst those at high risk of ill-health and social exclusion, such as those over 80, the poor or those who live alone, impacts could be large but confined to a small strata of the population. If, by contrast, the responses were more uniform, individual gains might be smaller but spread more widely. (Cutler, 2004)

[18] This could be extended to allow for non-users in any particular period to gain in expectation, if there is a positive probability that they will choose a bus journey

# 4 Travel Data and Empirical Method

## 4.1 Data

### 4.1.1 Outcome Data - The National Travel Survey (NTS)

The NTS is a continuous cross-sectional survey, which provides data on personal travel and monitors changes in travel behaviour over time in Great Britain[19]. The survey has two components: an interview, which provides detailed socioeconomic and demographic characteristics at the household and individual level; and, a seven day travel diary where each household member is asked to provide detailed records for every journey made in the given week (with random start day). Eighty-seven percent of those who respond to the interview complete the travel diary. All results are weighted to take account of this non-response.

The main sample includes all 29,112 individuals aged 45 and over, living in England, who completed both the interview and travel diary between January 2004 and March 2008. These individuals are divided into the four treatment and control groups as follows: 44 percent treated, 38 percent age controls, nine percent geographical controls, and nine percent age/geographic controls. A further sample of 5,206 individuals is available from the period April to December 2008, after geographic restrictions on pass use had been removed.

Principal outcomes are journeys recorded in the travel diary, broken down by mode and purpose. All journeys are weighted to account for the "drop-off" in reporting across the seven days of the travel diary, making journey totals continuous. The NTS interview provides two sets of supplementary outcomes: whether the individual owns a concessionary pass; and, the self-reported general frequency with which the individual walks, uses the bus, and takes the train.

Table 2 presents pre-reform summary statistics for selected outcomes. Differences across groups have no causal interpretation, as Treatment and Control LAs would almost certainly differ irrespective of concessionary travel arrangements. Prior to the reform, pass ownership rates were 45 percent amongst the treatment group, compared to 82 percent amongst the age controls. In each age group, more bus journeys are made in Control LAs, whilst car use is higher in Treatment LAs. At the extensive margin, a higher proportion of older people report at least one bus journey in both Treatment and Control LAs. At the intensive margin, total bus journeys, conditional upon using the bus, do not vary by age (4.8/week in Treatment

[19]Each year, households are selected using stratified two-stage random probability sample of private households in Great Britain. The first stage selects 684 geographical Primary Sampling Units (PSUs), or postcode sectors (from a total of 1,368); the second selects addresses within the PSUs (15,048 - 22 per PSU). Surveying is spread across 12 months of the year.

LAs, 6.3/week in Control LAs). Total journeys across all modes decline with age, and are approximately ten percent higher in Treatment LAs. Mean differences across the age cohorts are the product of a gradual ageing process, rather than any discontinuous change at 60 or 65: total number of journeys and number of car journeys decrease linearly from the age of 50, whilst bus use increases from 50 until approximately 78. Those in the bottom two income quintiles make fewer total journeys and car journeys, but more bus journeys, at all ages.

#### 4.1.2 Additional Local Authority Characteristics

Time fixed local authority characteristics are drawn from the 2001 census, and are comprised of percentages of men unskilled, households with no car, individuals over 60, and commuting by mode. As Control LAs are disproportionately urban, a higher proportion have no car and more people commute by bus. However, there is no difference in percent unskilled. Time varying controls include: quarterly unemployment and median male full time weekly wages (annual), provided by NOMIS; annual local government expenditure on highway maintenance planning policy and strategy, public and other transport planning policy and strategy, road safety, street lighting, and support for bus operators (excluding concessionary fare reimbursement), is provided by the Department for Communities and Local Government; and, petrol and diesel prices by month at the national level, from Dept. of Energy and Climate Change.

### 4.2 Empirical Method

The treatment and control groups, defined in section 2.3, differ significantly on observable characteristics and in pre-policy travel demand. As such, cross-sectional comparisons are highly misleading. The effects of the reform are therefore estimated using a difference-in-difference-in-difference (DDD) approach, exploiting both age and geographic sources of treatment variation. Validity rests upon the assumption equal time trends across Treatment and Control LAs, within age groups.

The presence of the geographic control group (aged 60+ in Control LAs) serves two purposes. First, to distinguish between contemporaneous shocks or time trends at the age group level, such as national policies directed towards older people. Second, to test that results are not strongly influenced by spillovers upon the ineligible. As the 2006 reform covered only local travel, geographic controls should not benefit. This is not necessarily true of the age control group, who could be affected through joint travel decisions with older spouses and friends or the intra-household allocation of trips. The main concern with the geographic comparison is that the substantive differences between Treatment and Control

LAs could give rise to differential trends. Under the assumption of equal time trends and no-spillovers, the impact of the reform should be identical when using a separate age DD (sample restricted to Treatment LAs) and geographic DD (sample restricted to those aged 60+) .

The baseline DDD specification for the travel outcomes, $Q$, of individual $i$, in local authority $l$, at time, $t$, is as follows:

$$\begin{aligned} Q_{ilt} = &\beta_1(EligAge_i * PostFBP_t * TreatLA_l) \\ &+ \beta_2(EligAge_i * PostFBP_t) + \beta_3(TreatLA_l * PostFBP_t) + \alpha_4(TreatLA_l * EligAge_i) \\ &+ \alpha_1 TreatLA_l + \alpha_2 EligAge_i + \alpha_3 PostFBP_t \\ &+ \nu Time_t + \theta \mathbf{LA_l} + \omega \mathbf{TV_{lt}} + \tau \mathbf{X_{ilt}} + \varepsilon_{ilt} \end{aligned} \quad (2)$$

where $EligAge_i$ and $TreatLA_l$ are indicators for whether the individual is over 60 and lives in a Treatment LA, $PostFBP_t$ is a dummy that takes the value one after April 2006, $Time_t$ capture aggregate time effects (month and year), $\mathbf{LA_l}$ and $\mathbf{TV_{lt}}$ represent fixed and time varying LA characteristics, and $\mathbf{X_{ilt}}$ are individual level characteristics assumed exogenous to the reform[20]. The error term, $\varepsilon_{ilt}$, is heteroskedasticity robust and clustered at the local authority level (360 clusters). The specification is estimated using OLS when $Q_{ilt}$ is continuous, a Tobit model where $Q_{ilt}$ is censored at zero, and by a linear probability model (LPM) when $Q_{ilt}$ is binary; $\varepsilon_{ilt}$ then follows the corresponding normal or truncated normal distribution[21].

Under the baseline DDD specification, the policy effects are estimated by $\widehat{\beta_1}$, the differential effect upon individuals who are 60 and over and live in Treatment LAs. When the sample includes just Treatment LAs, the specification reduces to an age DD, and policy effects are measured by $\widehat{\beta_2}$. When the sample is restricted to those over 60, the specification reduces to a geographic DD, with policy impacts estimated by $\widehat{\beta_3}$. For ease of interpretation, Tobit results will be given in terms of the average marginal effects (AME) (an average of the (partial) marginal effects calculated for each observation in the data). Tables will display AMEs/coefficients just for $PostFBP_t$ and its interactions.

The vectors $\mathbf{LA_l}$ and $\mathbf{X_{ilt}}$ control for any observable changes in the composition of the treatment and control groups over time, and make estimates more precise by reducing $\varepsilon_{ilt}$

[20]Individual characteristics include a cubic in age, gender, socioeconomic status, martial status, household structure, income quintile tenure type, walking distance from bus stop, and bus distance from a rail station

[21]To ensure that Tobit results are not driven by the strong homoskedasticity and normality assumptions, we check the robustness using Poisson specifications. LPM is used as interaction co-efficients on non-linear DD models, such as logit and probit, can be misleading.

(Angrist & Pischke, 2009). All individual level characteristics are drawn from the NTS. $\mathbf{LA_l}$ includes both local area characteristics from the 2001 census[22], and 49 county dummies. $\mathbf{TV_{lt}}$ controls for potential sources of omitted LA specific trends in travel incentives. The vector comprises LA and PSU population density, as provided by the NTS, plus additional information on the local economy and LA transport related expenditure[23]. (Angrist & Pischke, 2009)

Baseline results focus upon the FBP reform in 2006, and thus use data up to March 2008. Robustness tests allow for differential time trends by county pre- and post-reform, examine clustering at the more aggregated county level, and consider effects on high density Treatment LAs, which are more similar to the Control LA sample.

# 5 Travel Behaviour

## 5.1 Descriptive Evidence

Figures 1, 2, and 3 provide descriptive evidence of travel responses to the reform, produced using univariate kernel regressions. Figure 1 shows the proportion of people over 60 who reported owning a concessionary pass by month, between January 2004 and December 2008. The series for Treatment LAs shows a clear discontinuity at the start of 2006, just before the FBP policy was introduced. Since 2006, the rise in pass ownership is close to linear, exceeding 70 percent by early 2008. The corresponding series for Control LAs shows high take up throughout the period, with no evidence of any changes post-reform. As passes have been free to obtain since 2001, the rise in take up is attributable solely to the change in the rate of concession and the surrounding publicity.

Figures 2 and 3 plot smoothed mean bus journeys recorded in the 7 day travel diary, by age, pre- and post-reform. The shaded areas show 95 percent confidence intervals for each series. Figure 2 considers just Treatment LAs, and thus describes changes in usage amongst the treatment and age control groups. In the post-reform period, mean bus use tracks pre-reform usage up to age 60, before rising steeply thereafter; post-reform bus use is higher for every age between 60 and 72. The confidence intervals do not overlap between ages 65 and 72, suggesting a statistically significant rise in bus journeys. Figure 3 considers series for Treatment and Control LAs side by side, thus covering all treatment and control groups used

[22]Including percentages of men unskilled, households with no car, people over 60, and commuting by mode

[23]Including quarterly unemployment, annual median male weekly wages, annual local government expenditure on highway maintenance planning policy and strategy, public and other transport planning policy and strategy, road safety, street lighting, and support for bus operators (excluding concessionary fare reimbursement). Petrol and diesel prices are given by month, but at the national level.

in the DDD estimation. The rise in usage seen in Figure 2 is still visible, but is less apparent due to the change in scale. Levels of bus travel are much higher in Control LAs in both periods, but smaller sample sizes mean than the series has much larger confidence intervals. Nevertheless, there no evidence of a corresponding change in the trend post-reform.

## 5.2 Baseline Results

### 5.2.1 Bus Use

Table 3 considers the impact of the FBP policy upon average pass ownership and bus use. All specifications include a full set of individual and local authority controls, and data up until March 2008. The dependent variable in column 1 is a dummy for whether the individual holds a concessionary pass. Given that only those over 60 are eligible, the effects of the reform are estimated using a geographic DD (sample aged 60+). As suggested by Figure 1, the reform had a positive effect on pass ownership, equal to an average rise of 15 percentage points and significant at the one percent level[24]. The surge in pass ownership demonstrates that the policy encouraged more individuals to consider bus travel. Yet, benefits from the reform are contingent upon pass use; the remaining 4 columns thus use the DDD approach to estimate effects upon bus usage.

Columns 2 to 4 present AMEs of the reform upon (weekly) bus journeys recorded in the travel diary, calculated using the results from a DDD Tobit specification[25]. Results in column 2 indicate an average rise in recorded bus journeys of 0.33 for the treatment group, which is statistically significant at the five percent level. This represents an increase in usage of a third, and fits with the travel literature consensus that the short-run (own) price elasticity for local bus travel is between -0.2 and -0.4 (Balcombe et al., 2004). All other AMEs in column 2 are small, negative, and not statistically significant, suggesting that the reform had no spillovers upon the control groups.

In columns 3 and 4 the effect on observed journeys is separated into impacts at the extensive and intensive margins of travel. Theory predicts a positive extensive marginal effect, as reduced fares induce more travel; intensive margin effects could be of either sign, as the probable low usage by new users will counteract any increase amongst existing travellers. At the extensive margin, presented in column 3, the reform is associated with by a 4.9

[24]The coefficient attached to the $PostFBP_t$ dummy is negative (less than one), but is cancelled out by 2007 and 2008 year dummies.

[25]The marginal effect on the observed outcome (including zeros), $\frac{\partial E(Q|Z)}{\partial z_k}$, is equal to $\beta_k \Phi(\frac{z\beta}{\sigma})$, where $\beta_k$ is the estimated coefficient from the Tobit regression. Extensive marginal effects are given by: $\frac{\partial Pr(Q>0|Z)}{\partial z_k} = \phi(\frac{z\beta}{\sigma})\frac{\beta_k}{\sigma}$. Intensive marginal effects are equal to the following: $\frac{\partial E(Q|Z,Q>0)}{\partial z_k} = \beta_k + \beta_k \frac{\partial \lambda(c)}{\partial c}$, where $\lambda(c)$ is the inverse mills ratio, and $c$ is $\frac{\mathbf{Z}'\beta}{\sigma}$.

percentage point increase in the probability of recording at least one journey. In column 4, the expected number of bus journeys, conditional upon making at least one trip, rises by 0.34. At both margins, the magnitudes are larger than moving from the third to the first (poorest) income quintile. To check the consistency of the DDD results, estimated effects under an "age DD" and "geographic DD" are considered separately. The estimated policy effects are not statistically different from each other, or the baseline specification, at either the extensive or intensive margin. This substantially reduces the potential for confounding differential trends, which would need to be separate but of an identical direction and magnitude[26].

Column 5 reports ordered probit results for the effects of the FBP upon general frequency of bus use, as recorded in the NTS interview[27]. The coefficient is hard to interpret, but the positive and statistically significant effect is consistent with the results from columns 1 to 4. One implication is that travellers both recognise and acknowledge that they are using the bus more often. Again, the magnitude of the policy effect is approximately equal to moving from the third to the first income quintile.

There is a positive trend in both pass take up and bus usage over the first two years of the reform. In year one, (April 2006 to March 2007), pass ownership rose by 11.1 percentage points and average weekly/annual bus journeys increased by 0.29/15.1. In year two (April 2007 to March 2008), the cumulative rise in pass ownership was 17.1 percentage points, whilst recorded bus journeys increased by at total of 0.38/19.8[28]. These increases in magnitude are not statistically significant, but the maintenance of higher bus usage does show that reform effects did not die out after the initial publicity from the reform had subsided. Long-run benefits of the reform require that travel responses are sustained into the future[29]. Any increase in the travel responses over time would improve the cost effectiveness of the reform, by reducing the average fiscal cost per journey.

Conditional upon the inclusion of a Post FBP time trend, the 2008 national reform has no additional effects upon bus travel demand in its first eight months. The absence of an effect, at least in the short term, is perhaps unsurprising as buses are typically used for local

[26]To relax the assumption of a normally distributed error term, the baseline specification is re-estimated using a Poisson specification. The AME on total journeys is 0.334 (0.157), and not statistically different to the AME in column 2. The LPM estimates for the effect of the reform upon reporting at least one bus journey is equal to 0.0656 (0.0291), and not statistically different from that in column 3.

[27]Available categories are as follows: three or more times a week; once or twice a week; less than once per week, more than twice a month; once or twice a month; less than once a month, more than twice a year; once or twice a year ; less than once a year or never. The question was not asked in 2005; the sample size is correspondingly smaller.

[28]These estimates are produced by replacing the $PostFBP_t$ indicator with a categorical variable, equal to zero pre-reform, one in year one, and two in year two, which is then interacted with $TreatLA_l$ and $EligAge_i$ as in (2).

[29]For example, the strong protective effects of physical activity upon cardiovascular disease is transient, swiftly dropping as soon as activity levels fall. (Chief Medical Officer, 2004)

journeys, with 75 percent of bus trips taken by older people covering a distance of under five miles. A series of specification tests, presented in Appendix B.1, find that results are robust to allowing for county × year fixed effects, and to clustering at the more aggregated county level.

### 5.2.2 The Marginal User

The results in Table 3 indicate that the reform increased demand for bus travel, a necessary precondition for the three potential benefits of the policy outlined in section 2. However, the nature and distribution of any benefits will depend upon the characteristics of the marginal user. As described by the model in section 3, any variation in travel demand across individuals can be generated through number a of different channels. Income elasticity of demand will depend upon individual income, $y_i$, and an individual's marginal valuation of income, $\alpha_i$. In addition, each journey type will have a set of observable characteristics or attributes, $Act_{ita}$, which affects the attractiveness of the journey with price held constant; both the set of journey attributes, and the tastes for those attributes, $\mu_{it}$, may differ across individuals.

The most basic *a priori* source of heterogeneity is age, which is correlated with health, mobility, poverty and social exclusion, and could thus enter $v_{ita}$ through $\alpha_i$ $y_i$, $Act_{ita}$ or $\mu_{it}$. Pre-reform travel data indicates that car and total journeys decline with age, whilst bus travel rises until the late 70s. However, the impact of age upon travel responses to the reform is ambiguous. Most people retire from work between 60 and 70, giving more time to use the off-peak pass[30]. Yet, age also increases the risk of ill-health and impaired mobility[31]. Moderate health impairments can increase travel as people give up driving; but, as conditions becoming more severe, the ability to make journeys and use buses becomes restricted. Any variation in the effects of the reform by age will therefore be determined by the competing forces of time available, transport alternatives, and mobility. (Balcombe et al., 2004)

To test variations in travel response, the $EligAge_i$ dummy in the baseline specifications is replaced by four age categories (45-59, 60-64, 65-74, 75+, with the 45-59 age dummy omitted). Results from the full DDD specification replicate the patterns suggested by Figure 3. In particular, the reform is associated with a increase demand for bus travel amongst those aged 60-64, significant at the ten percent level, and 65-74, significant at the five percent level; AMEs are largest for the 65-74 age group, equal to 7.6 percentage points at the extensive margin, and 0.44 journeys at the intensive margin. However, large standard errors mean that

[30] NTS data suggests that 25 percent of people have retired by 59, rising to over 90 percent at age 70. Much of the rise takes place at the default state retirement ages of 60 for women and 65 for men.

[31] For example, death rates, one measure of the risk of ill-health, increase exponentially after the age of 45. As such, male deaths per 100 population rise from 14 at age 65 to 38 at age 75 and 116 at age 85; the corresponding figures for women are 9, 25 and 86.

one cannot reject the hypothesis that the effect of the policy does not vary by age group. When the sample is restricted to Treatment LAs, age DD results indicate positive effects of the reform upon all eligible age groups, statistically significant at the one percent level. The estimated AMEs are all of similar magnitude (0.19 to 0.25 journeys) and, again, do not differ significantly from one another.

Alternative sources of variation in travel responses are local area characteristics, which determine ease of access to transport and enter into $Act_{ita}$, and individual characteristics that affect tastes ($\mu_{it}$) and the role of income ($y_i$ and $\alpha_i$). To test for heterogeneity by area type, the sample is split into quintiles by LA population density. The top 40 percent of the sample is defined as residing high density areas (at least 14 persons/hectare), and the bottom 60 percent in low density areas. The effects of the reform upon the two groups are then estimated using separate age DDs with age band indicators. Controls LAs are excluded, as there is no support in the low density sample. Results for the high density sample indicate the effects of policy were positive and statistically significant at the one percent level for all eligible age groups, with AMEs ranging from 0.57 and 0.74 journeys per week. In the low density sample, estimated policy effects are much smaller and only statistically significant at the ten percent level for those aged 65-74 (a rise of 0.13 journeys). Differences in the estimated effects between the high and low density samples are statistically significant at the one percent level.[32]

Specifications that test for heterogeneity by individual characteristics, including sex, income, socio-economic group, single person households, and car access, find no statistically significant variations. In most cases, policy coefficients are small, rather than just poorly determined[33]. The reform thus appears to have increased the level of bus travel, whilst maintaining (within treatment group) cross-sectional differences. These results from the NTS mirror local studies, which have suggested that new users are on average richer, more likely to own a car, and from areas with a lower population density, than pre-existing users[34]. However, one should not ignore the increases in bus usage amongst traditionally high bus use groups, whose behaviour might be influenced by both the change in price and the response of their richer peers. (Rye & Mykura, 2009; Baker & White, 2010; Integrated Transport Planning Ltd, 2009)

[32]Specifications for heterogeneity by age and population density are presented in Appendix, section B.2

[33]For example, the Tobit coefficient for the effect upon being low income (bottom two quintiles) is 2.4, whilst the relevant policy interaction term is equal to -0.4; the effect of being female is equal to 4, but the policy interaction is 0.25.

[34]The data and methodologies used by these local studies is very different. Baker and White (2010) presents a case study from Salisbury District Council, a largely rural district. Data comes from 796 pass holders. Rye and Mykura (2009) cover responses to a similar reform in Scotland (in 2002), and use self-completion questionnaires from pass holders, bus stop surveys, and focus groups.

### 5.2.3 The Marginal Trip

A journey is defined by the combination of a mode and a destination. Turning back to the model, the FBP policy acts to increase the indirect utility from all journeys that involve bus travel, $v_{ib'}$; this acts to increase the probability that bus travel is chosen, relative to home consumption or journeys using other modes. Additional bus trips may therefore represent new journeys, or substitutions from other modes. Equally, the sensitivity of $v_{ib'}$ to the reform may vary by destination, inducing a change in the distribution of journeys across purposes.

Table 4 considers the effects of the reform upon alternative travel modes. Column 1 repeats column 2 of Table 3. Columns 2-5 present the corresponding specifications for car, car passenger, walking, and rail journeys. Policy coefficients are not statistically significant for any mode other than bus travel. There is no statistically significant reduction in car journeys at the mean, by household cars, or income quintile[35]. Walking journeys do not fall, even for households without a car[36].

The limited substitutions across modes suggest that additional bus trips represent new journeys. This proposition is tested directly in column 6 and 7, which consider total journeys including and excluding bus travel. In column 6, the policy is associated with a 0.42 increase in total journeys, but the coefficient is not statistically significant. However, standard errors for all variables, in all columns of Table 4, are large, making any small changes hard to capture. When bus journeys are excluded, in column 7, the estimated coefficient falls to 0.11. The difference between columns 6 and 7, is therefore almost exactly equal to the observed increase in bus use, at 0.34. There is therefore indicative, if not compelling evidence, that the reform increased the average total number of journeys.

When bus journeys are broken down by purpose, there are statistically significant increases in trips made for non-food shopping and social purposes other than visiting friends and relatives (both at the five percent level). For non-food shopping, journeys increased by an average of 0.09 (2.9 percentage points at extensive margin, and 0.16 journeys at the intensive margin); for non-friend/relations social activities, the average marginal increase was 0.07 journeys (2.5 percentage points at the extensive margin and 0.19 journeys at the intensive margin). The effects upon non-medical personal journeys are smaller (0.04 journeys), and not statistically significant. For all other journey categories (work, food shopping, personal medical, and social visiting friends/relations), estimated coefficients both lack statistical significance and are close to zero. The types of journey affected by the reform therefore appear discretionary, rather than fulfilling basic needs, which fits with the apparent lack of mode

[35] This fits with some evidence from the travel literature that free travel in the CBD and for elderly people does not lead to substitutions away from car travel (Balcombe et al., 2004).

[36] Effects on walking distance and short walks are similarly positive but not statistically significant.

substitution. Further checks test for substitutions between modes, within journeys purpose; again, there is no evidence that increase bus journeys represent mode substitutions.

As an alternative test for changes in traffic volumes, we consider data on road traffic accidents collected by the police. Reports cover all incidents that involve casualties, and include the precise geographic location of the accident, and the age and gender of the driver(s) and any pedestrians. The effect of the reform on monthly LA road traffic accident rates is estimated using a DDD specification. Results indicate that there are no effects on accident rates amongst drivers or pedestrians over 60, or at any other age cut off. This is consistent with the results from the NTS, which suggest no statistically significant journey substitutions away from car travel.

## 5.3 Econometric Concerns and Robustness

The validity of the results presented thus far rests on the assumption of equal time trends. Although this assumption cannot be tested directly, one can establish whether there were differences in pre-reform trends and control for possible contemporaneous shocks to travel incentives.

To test for pre-reform differential time trends, we consider NTS data from April 2002 to March 2006. Indicators are created for the 16 quarters in the data. Travel outcomes are then regressed against a full set of individual and LA controls, plus interactions between the quarter dummies and treatment/control group indicators. The treatment group is omitted, and joint significance tests on the quarter interactions examine potential differential time trends for each control group. For the age control group, there is no statistically different trends in bus or car use; but, quarter interactions are jointly significant at the ten percent level for walking journeys and total journeys. Results for the geographic control group indicate no statistically significant differences in time trends for bus or walking journeys; interactions terms for car journeys and total journeys are statistically different from zero at the ten percent and five percent levels, respectively. There are no statistical differences in trends between the treatment and the remaining age/geographic control group (aged $<60$, in Control LAs). Where quarter interactions are jointly significant, coefficients are not increasing or decreasing monotonically over time, which would indicate an underlying differential trend. Moreover, statistical significance is typically driven by one or two quarters, which is removed when those quarters are dropped[37].

Contemporaneous shocks to travel behaviour will bias results, if there are differential

[37] For example, the statistically significant difference in time effects on total journeys, between the treatment group and geographic control group, is removed when the second quarter of 2003 is dropped from the specification.

effects upon treatment and control groups. The local authority controls for transport related expenditure, coupled with the consistency of the results across the two separate DDs, go some way to allay these fears[38]. Foremost amongst the remaining unobserved and potentially confounding factors are bus fares, which companies have refused to provide at an LA level. As companies are reimbursed for concessions on the basis of forgone revenues, there is an incentive to increase adult fares. Any reform-induced rise could bias results upwards, if the age control group respond by reducing their bus use. However, evidence considered thus far does not suggest that such a bias is substantive: Figure 2 indicates that bus use amongst 45 to 59 year olds did not change markedly post-reform; and, results are robust to the inclusion of year × county fixed effects that would absorb changes in fare (see Appendix B.1). As a further check, (quarterly) adult fare prices are imputed using a hedonic regression and journey level data from the travel diary. The only above inflation fare rises occurred in 2008. However, this coincided with the leap in global oil prices and may therefore be unrelated to the reform. When imputed fares are added (4), all results remain unchanged; any changes in policy coefficients are tiny and not statistically significant[39].

# 6 Beyond Travel

The FBP reform generated a sizable travel response. However, the real benefits of the reform should stem from activities associated with increased travel, rather than the journeys themselves. This section considers the evidence on the effects of the reform upon outcomes discussed in section 2.1, physical activity, service access and social participation. At least three factors mean any impacts might be small and hard to identify. First, results in section 5 indicate that travel responses do not vary by socioeconomic characteristics. Additional bus passengers are therefore relatively healthy and integrated into the community. Second,

[38]Regional data indicates no substantive change in bus punctuality rates between 2005 and 2007. Passenger surveys indicate the majority of existing bus users feel that levels of overcrowding have remained the same (Department for Transport, 2006, 2008; Integrated Transport Planning Ltd, 2009). Effects upon other areas of LA expenditure should also be limited, as funds come from central government. However, in 2008, half of all LAs reported shortfalls in funding. In our data period, the effects of such shortfall should be minimal, but continued underfunding could threaten the quality and density of bus network, or force spending cuts elsewhere. For Control LAs, the reform provides central government funding for services that was previously financed by local revenues, but this amounts to no more than three percent of total LA expenditure.

[39]Adult bus fares are imputed using bus stage level records of those aged 25 and 59, who receive no concessions. The dependent variable is reported stage cost, and independent variables include year, month, county time of day, distance, season ticket ownership, and all fixed and time varying controls. Predicted fares are then collapsed by county and quarter. Specifications adding predicting fares to (4) do not correct standard errors for the presence of an imputed independent variable. However, the invariance of policy coefficients to the inclusion or exclusion of bus fares, means that such a correction would not affect any of the results presented in this section.

data is only available up until 2008, whereas benefits from the reform may take years to emerge. Third, it is relatively rare to have data on the outcomes in question, in time series. This section uses Sport England's Active People Survey (APS) to assess the impacts upon physical activity, and the English Longitudinal Study of Ageing (ELSA) to estimate effects upon service access. The impacts upon social participation are evaluated using both the APS and ELSA.

## 6.1 Physical Activity

### 6.1.1 Data and Empirical Method

The Active People Survey (APS) is commissioned by Sport England, with the objective of measuring participation in sport and active recreation. The sample is nationally representative of those aged 16 and over, and is collected as a repeated cross section[40]. Individuals are asked about walking, cycling, and their participation in an exhaustive list of sports, over the previous 28 days. The first survey, APS1, was conducted between October 2005 and October 2006, generating a total sample of 363,724 interviews and providing six months of pre-reform data; the second survey, APS2, began in October 2007,and ended October 2008, with 191,325 interviews. Our sample includes 155,177 individuals aged 45 and over, responding in the first six months of each survey (October - April)[41]. As the sample is nationally representative, and includes LA identifiers, it is possible to identify Treatment and Control LAs. Age is only given in ten year intervals, which, in our sample, comprise 45-54, 55-64, 65-74 and 75+; unfortunately, this means that the eligibility of those aged 55-64 is not determined. The survey also records a range of individual and household characteristics, but respondents are not asked about transport use.

Questions on walking behaviour include whether respondents walked continuously for 30 minutes at least once over the past four weeks, the number of days walked at a moderate intensity, and the number of days walked for health and recreation. The theoretical effect of the FBP reform upon walking is ambiguous: individuals may substitute away from walking journeys, but could also increase walking when making additional journeys or substituting from more passive modes. Results from the NTS indicate no substitution from walking journeys, and suggest that extra journeys represent new trips. If these results hold, one would expect the effect upon walking to be weakly positive. Significant effects on broader sporting and recreational participation would indicate spillovers upon types behaviour, less

[40] The sample is generated using Random Digit Dialing (RDD). Survey respondents were either the sole household member aged 16+, or the household member over 16, with the next birthday in the calendar year).

[41] October 2005 to April 2006 is the only pre-reform data available; the same months are chosen for APS2, so that the sample is not biased by seasonal fluctuations in behaviour.

directly related to travel. Data is available on the days and minutes spent participating in each sport or recreational activity, in the previous four weeks. These are added up over sports, to give aggregate measures of participation.

Effects of the reform are estimated using the same DDD approach used for the NTS, with the $PostFBP_t$ dummy replaced by an indicator for APS2. Given the large sample size, and the ambiguous eligibility of those in the 55-64 age group, the $EligAge_i$ indicator is replaced by age band indicators (45-54, 55-64, 65-74, and 75+, with the 45-54 group omitted)[42].

### 6.1.2 Results

Table 5 presents the AMEs of the reform upon the number of days on which respondents walked at a moderate intensity, for at least 30 minutes. Data from wave 1 indicates that days of moderate walking fall monotonically with age, from approximately four, for those 45-54, to just above one, for those aged 75 and over. This is attributable to declines at the extensive rather than the intensive margin[43]. Column 1 shows DDD estimates of the effect of the FBP reform using the whole sample. Average effects on observed walking are above 0.5 days for those aged 65 and over, but only statistically significant at the ten percent level for those aged 65-74. Interactions between the $APS_t$ indicator and the relevant age group dummies have negative signs and are not statistically significant, indicating no change in behaviour amongst the geographic control group. Equally, the $APS_t \times TreatLA_l$ interaction suggests no spillovers upon the age control group. In column 2, the sample is restricted to high population density areas (top two quintiles). Average marginal effects are larger than for the sample as whole, with a rise of 0.9 days for those 65-74 (significant at the five percent level) and 1.1 days for those 75+ (significant at the ten percent level). Although the AMEs in columns 1 and 2 are not statistically different from one another, the pattern is similar to that observed for travel responses in section 5.

In Columns 3 and 4, the sample is restricted to APS respondents in Treatment LAs. The $APS_t$/age dummy interactions suggest a possible negative time effect amongst older people in Control LAs, although this is not statistically significant. The age DD could therefore underestimate the impact of the reform, if there is an underlying negative time trend. However, removing the relatively small sample of Control LAs substantially improves

[42]The full specification includes individual and household control from the APS. These include household income (decile), size and car ownership, housing tenure, and the sex and terminal age of education of the respondent. The same time fixed local authority controls and county dummies are used as for the NTS analysis, plus an APS supplied index of multiple deprivation. Standard errors are clustered at the local authority level.

[43]The proportion making at least one moderate walking journey falls from 0.33 to 0.08, whilst the number of walking days conditional upon making at least one rises from 12.3 to 14.7. All figures are for Treatment LAs only.

the precision of the results. In column 3, which contains all Treatment LAs, the reform is associated with an average rise in walking of 0.3 days amongst those aged 65-74, significant at the one percent level. When the sample is restricted to high density Treatment LAs (at least 14 persons/hectare), in column 4, the AMEs of the reform for those aged 65-74 and 75+ are both equal to 0.6 days and statistically significant at the five percent level. The magnitudes of these policy effects compare to the one day decline in walking for every increase in (ten year) age band. However, the purpose of journeys is not specified and there is no information on travel behaviour; the mechanisms linking increased walking and the FBP reform are therefore unclear. Results are very similar when the outcome variable is a dummy for walking for at least 30 minutes, at least once in the past 28 days. By contrast, there are no statistically significant effects on the number of days the respondent reported walking for health purposes.

Walking is the most common form of physical activity reported by older adults, across a range of surveys. The increases generated by the reform are consistent with existing evidence that finds a positive association between public transport use and walking activity. Both observational studies and interventions indicate that walking can help protect against, and manage, CVD (Murtagh et al., 2010). Further benefits of physical activities, such as walking, include reduced blood pressure and some protection from type 2 diabetes and dementia. (Chief Medical Officer, 2004; Erickson et al., 2010)

In contrast to the results for walking, there is no evidence of any effect of the reform upon sporting participation. Equally, the reform has no impact upon sports with a high proportion of older participants, including swimming, lawn bowls, and ballroom dancing. Evidence from the APS therefore suggests that the reform may have increased walking, perhaps in the course of making journeys, but had no effect on participation in leisure activities not directly related to travel.

## 6.2 Service Access

### 6.2.1 The English Longitudinal Study of Ageing (ELSA)

ELSA is a panel of individuals aged 50 and over living in England. The original wave was conducted in 2002, and consisted of 12,100 members; three subsequent waves followed in 2004, 2006 and 2008. As wave three commenced in May 2006, there are two pre- and two post-reform waves. The sample is nationally representative, and thus contains all four treatment and control groups. Each wave is comprised of a face-to-face interview and a self-completion questionnaire. Sample sizes for the self-completion questions are smaller, as ten percent of those interviewed do not return the questionnaire, and vary by question, as some answers are left blank or incomplete. Our baseline sample includes those cohort members present in all four waves, a total of 6,200 individuals (see Appendix C for a sample description).

Although ELSA provides the best available data on the older population in England, the timing of the FBP policy creates two problems. First, the original sample is not refreshed until 2006. The proportion aged under 60 thus more than halves between 2002 and 2008; those that remain are aged 56-59, where the policy could have the greatest spillovers. Second, the wording and response categories to the one question asking about public transport changes between 2004 and 2006, precisely at the same time as the reform. It is therefore impossible to determine who changed reported bus use between waves two and three[44].

Policy effects are estimated using separate age and geographic DDs, to ensure that no individual changed their eligibility for free travel for any reason other than the reform. All specifications include random effects.

#### 6.2.2 Access to Service Measures

In 2002, 2004 and 2008, ELSA cohort members are asked about their ease of access to ten different services (bank, chiropody, dentist, GP, hospital, local shop, shopping and supermarket). As the questions are part of the self-response questionnaire, responses are not available for all sample members in all years. The sample of individuals who have a full set of access answers is around 4,300, but varies slightly by question. The focus here is upon two services, the Post Office, and GPs (general practitioners or primary care physicians). Post Offices both provide postal services, and distribute pensions and welfare payments to those without bank accounts. GPs diagnose conditions, provide drug prescriptions, advise upon preventative care, and are the gateway to all other NHS services; access is therefore crucial for both the short-run and long-run health.

Respondents are asked to categorise access to each service, using the following options: very easy, quite easy, quite difficult, very difficult, unable to go, and do not wish to go. Over 90 percent of individuals report that access is “quite” or “very easy”, generating little variation. The dependent variables are therefore indicators for whether the individual reports that access is “very easy”. In 2004, 71 percent reported very easy access to post offices, and 70 percent very easy access to GPs. The effects of the reform are estimated using random effects LPM specifications, within treatment and control LAs[45].

[44] In 2002 and 2004 the categories were: a lot, quite often, sometimes, rarely, and never. In 2006 and 2008 the categories were changed to: every day or nearly every day, two or three times a week, once a week, two or three times a month, once a month or less, and never.

[45] The Breusch and Pagan Lagrangian multiplier test provides strong evidence for the presence of random effects. Specifications are estimated using both random effects and fixed effects, but the estimated coefficients

#### 6.2.3 Results

Table 6 presents the effects reform upon access to Post Offices (columns 1-4) and GPs (columns 5-8)[46]. In column 1, the sample is restricted to cohort members in treatment LAs, who reported using buses at least sometimes. Column 1 considers the average effect of the FBP reform on reported access to Post Offices amongst sample members in Treatment LAs, who reported using buses at least sometimes in 2004. Results indicate that the policy is associated with a 6.1 percentage point increase in the probability of reporting very easy access, which is statistically significant at the one percent level. When the $EligAge_{it}$ indicator is replaced by age band dummies ($<$ 60, 60-64, 65-74, and 75+), in column 2, AMEs are statistically significant at the five percent level and do not vary across eligible age groups. In columns 3 and 4, the sample is split into cohort members who reported using buses at least "sometimes" in 2004, and those who used the bus rarely or never. Non-users may respond to the reform, but one would expect larger access improvements for bus users, who experience greater first order effects from the reduced cost of travel and typically have fewer transport alternatives[47]. The results for bus users, in column 3, indicate a much greater rise in access than for the sample as a whole, with improvements of 14 to 19 percentage points. Estimated effects for non-users are corresponding smaller, at approximately one percentage point for each eligible age band. Differences between the policy coefficients in columns 3 and 4 are statistically significant at the one percent level.

Columns 5-8 repeat the same specifications for access to GPs. Column 5 indicates an average improvement in access of 3.9 percentage points, statistically significant at the 10 percent level, which column 6 indicates is concentrated in the over 75 age group (6.7 percentage points, significant at the five percent level). Bus users over 75 experience an improvement in access of 14.6 percentage points (column 7), whilst the reform has no significant effect upon non-users (column 8). However, relatively large standard errors mean that the coefficients in columns 7 and 8 are different from each other only at the ten percent level.

To further test the robustness of the results, the specifications used in Table 6 are repeated using only cohort members from Control LAs[48]. As the FBP reform did not change free travel

do not differ. The random effects estimator is therefore more efficient. All specifications include individual controls for a cubic in age, sex, income quintile in 2006, self-reported health in 2004, whether the respondent has any children, number of grandchildren, and whether the respondent smokes. Time fixed and local authority controls are the same as those used in section 5. The full DDD specification is not implemented, as specifications will split by prior bus use; the characteristics of bus users in treatment and control LAs are very different, prompting concerns of differential trends.

[46] In this case, AMEs refer to the marginal effect when all independent variables are at their average values.

[47] The outcome measures perceived access, and not use. The FBP policy should therefore have no income effects, even for poor pensioners or high volume existing users.

[48] A geographic DD is not used, as pre-existing bus users in Treatment and Control LAs are very different. Restricting on previous bus use could thus give rise to differential time trends or age effects. We assume

eligibility for any in this sample, the $PostFBP_t$ indicator should have no differential effects by age. For both Post Offices and GPs, results match expectations: interaction terms are typically negative and none are statistically significant.

The average five to seven percentage point rise in perceived access seems reasonable, given that results from the NTS suggested that the proportion of older people using buses rose by a similar magnitude. Marginal effects are larger for pre-existing users, which was impossible to ascertain using the cross-sectional travel or APS data. The absence of a clear pattern by age is more surprising. In full sample of wave 1 respondents (12,100), 84 percent of respondents aged 50-54 reported very easy access to post offices, falling by just five percentage points, to 79 percent, amongst those aged 64-69. The potential for access improvements is therefore limited. After age 70, the access measure falls much more rapidly, to 63 percent amongst those 74-79 and 45 percent for those 80-84; the same pattern is repeated for GPs. One might therefore expect more pronounced effects in the oldest age group, where access is declining faster. However, without information on the nature of barriers, and how those might vary by age, it is not clear what impediments the FBP policy is being used to overcome. Improvements in service access benefit older people, and particularly those over 75, by reducing the costs of service use and in maintaining perceptions of independence. Unpaid carers and the state gain, as older people are able to undertake more tasks for themselves, and for longer.

### 6.3 Social Participation

Measures of social participation are available from both ELSA and the APS. In ELSA, respondents are asked for information on their organisational membership, the frequency of participation leisure activities, and how often they meet up with friends and family. The APS provides supplementary data on participation in sporting and recreational activities.

In cross-section, there is a strong positive correlation between bus use and measures social participation. When the first wave of ELSA (2002) is considered in isolation, those who report using public transport at least sometimes have significantly higher organisational membership, participate in more leisure activities, and meet up with friends and friends more often. All the associated $\rho$-values are less than 0.001[49]. The FBP reform provides an exogenous variation in the relative attractiveness of bus travel, which could establish whether these relationships are causal.

Results from the APS and ELSA suggest that the reform did not have a significant effect

that those under and over 60 in the same area are comparable.

[49]Social participation outcomes are regressed against a dummy for using the bus, a cubic in age, indicators for housing tenure and monthly for expenditure (quintiles)

on social participation, using any measure. This is true even when we confine the sample to ELSA cohort members who report using public transport. Estimated coefficients are both not statistically significant and vary in sign. The key implication is that, at least at margin, the price of buses is a factor which limits social participation. In the active ageing and healthy ageing policy agendas, it has occasionally proved tempting to justify policies or programmes on the basis of strong cross-sectional correlations (see Oxley, 2009). Our results suggest that doing so is inadvisable.

# 7 Tentative Welfare Calculations

Potential welfare gains from the FBP reform are derived from two sources: the utility pensioners receive from bus trips, based on willingness to pay; and, the external or previously unobserved benefits associated with travel. Although the main focus of this paper has been on the latter, any attempt to gauge the cost effectiveness of reform must include both components. Moreover, gains on the basis of willingness to pay are far easier to approximate, and may be used as a benchmark for any calculations of external benefits.

Take the most simple example of a local bus market with one bus company, which operates as a natural monopoly. The market has two groups of segments, (working-age) adults and pensioners. Demand amongst pensioners is less price responsive, generating a steeper demand curve. The marginal cost of each journey is low, but sloping gently upwards.

Figure 4 depicts the pensioner market for bus travel. We assume that the bus company is able to perfectly price discriminate across segments. The firm therefore chooses a profit maximising price of $P_{S,P}$, and pensioners demand $Q_{S,P}$ bus trips. Consumers receive total utility $XP_{Max}OQ_{S,P}$, including a consumer surplus of $XP_{Max}P_{S,P}$. Total deadweight loss is equal to $XZY$. If the government then imposes a maximum price of zero, consumers receive total utility $P_{Max}OQ_{Max}$ at no cost, a gain of $XP_{S,P}OQ_{Max}$. Of this, consumers receive a transfer of $P_MOQ_{S,P}X$, for pre-existing journeys, and $XQ_{S,P}Q_{Max}$ for new journeys.

Under the "no better off no worse off" funding formula bus companies receive compensation for lost revenues ($P_MOQ_{S,P}X$) plus the marginal cost of any additional journeys ($TQ_{S,P}Q_{Max}W$). The net welfare gain is therefore given by $XZY$ (the region where consumer valuations are greater than marginal cost) minus $YQ_{Max}W$ (the region where marginal cost is greater than consumer valuations). The latter region should be very small, as government estimates for the marginal cost of travel are in the region of zero to fifteen pence (Department for Transport, 2010).

The welfare effects of the FBP policy are slightly harder to calculate than Figure 4 suggests, as a 50 percent concession already operated. On the consumer side, this implies that the pre-reform fare was not necessarily the profit maximising price in the pensioner market. However, as long as the pre-reform price is above the competitive level, $P_{C,P}$, the analysis and consumer welfare calculations remain identical. On the firm side, bus companies already received concession for the 50 percent concession. Fortunately, the fiscal cost of the reform does not require calculation, as exact figures are available from LA accounts. Table 7 presents the necessary figures for pre-reform adult bus fares, pre-reform pensioner demand for buses, the price elasticity of demand for bus travel amongst pensioners, and LA expenditure. All figures are averages and approximate. All calculations must therefore be viewed as back of the envelope estimates.

The benefit for pensioners can be decomposed into two parts. The first is a transfer for the monetary value of pre-existing journeys ($P_{S,P}OQ_{S,P}X$), which is equal to an average of £34 per person per year (54 journeys×£0.63). The second is value attached to additional journeys ($XQ_{S,P}Q_{Max}$). On a first order approximation this can be bounded between zero, assuming no benefit from additional journeys, and £11 (54 journeys×0.33×£0.63), assuming that all journeys are valued at a fraction below the pre-reform price. A second order approximation, assuming that demand is a linear function of price, suggests a valuation of £5.60 per person per year[50]. The approximate total gain to consumers is therefore £39.60 per person over 60 per year.

The fiscal cost of the FBP policy is equal to the difference between expenditure on concessions pre- and post- reform, an average of £24 per person over 60 in Treatment LAs (£46-£22). Subtracting these costs from the gains to pensioners gives a net benefit to society of £15.60 per person over 60 per year. Even if one assumes that all additional journeys carry zero net benefits, the total surplus is still positive (£10). All calculations assume that the "no better off, no worse off" funding formula is applied correctly, and that the reform does not affect prices in the adult market[51].

Results in section 6 suggest that external benefits from the reform are derived from increased walking and improved access to services. Whilst any benefits could be substantive, attaching a monetary value is difficult. There is a consensus amongst medical professionals and public health bodies that walking has a positive effect physical and mental health. However, the only figure available is from the New Zealand Transport Agency, who value

[50] This figure is given by halving the product of the change in price and the change in quantity: 0.5×(£0.63)×(54 journeys×-1×-0.33). In reality, the second order approximation should integrate under the hicksian demand curve, not the Marshallian demand curve. However, here income effects are assumed to be small, such that the two are close together. This is reasonable, given that bus travel represents a very small budget share. Demand is assumed to be a linear function of price.

[51] These calculations also do not consider the relative welfare gains from alternative government expenditure, or the cost of raising the budget for the reform in taxes. Any distortionary effects from general taxation would reduce the overall net gain.

walking at NZ\$2.60 or £1 per kilometer; benefits are assumed to be split equally between individuals and the rest of society (including the government) (NZTA, 2010). Taking the baseline rise of 0.5 days walking per month, with a total of 1.5km walked on each day, the total benefit is equal to £9 per person per year (0.5 days×1.5 km×12 months× £1). The estimated effect under the age DD is 0.3 extra days per month, or an average of £5.40 per person per year. Benefits to older people themselves are therefore £2.70 to £4.50 per person per year, compared to the £39.60 gain calculated on the basis of willingness to pay for bus travel. For the government, the external benefits from increased walking amount to between 11 and 19 percent of the total fiscal costs of the reform.

Providing a figure on the internal and external benefits of service access is more speculative. Although there is some potential for increased use to create congestion for others using amenities or public services, the net benefit should still be positive. Very basic welfare calculations therefore suggest that the reform generates an overall net gain for society. However, the benefits from the reduction in the deadweight loss from natural monopoly appear at least as large as any spillovers from activities associated with travel.

# 8 Discussion

This paper has considered how a reform granting free bus travel to the over 60s in England has affected travel behaviour, and the extent to which such behavioural changes support active ageing. The central results are as follows: (i) the reform increased bus use on all available measures; (ii) additional bus journeys represent new journeys, rather than substitutions across modes; (iii) responses were greater in medium to high population density areas, and tend to be larger for those age 65-74, but there there is no evidence of heterogeneity by individual or socioeconomic characteristics; (iv), APS data indicates an increase in walking, consistent with that associated with a rise bus use; (v) ELSA suggests an improvement in access to services for pre-existing bus users; and, (vi) the reform has no significant effects on social participation on any measure, in either survey. Together, these findings generate the following implications.

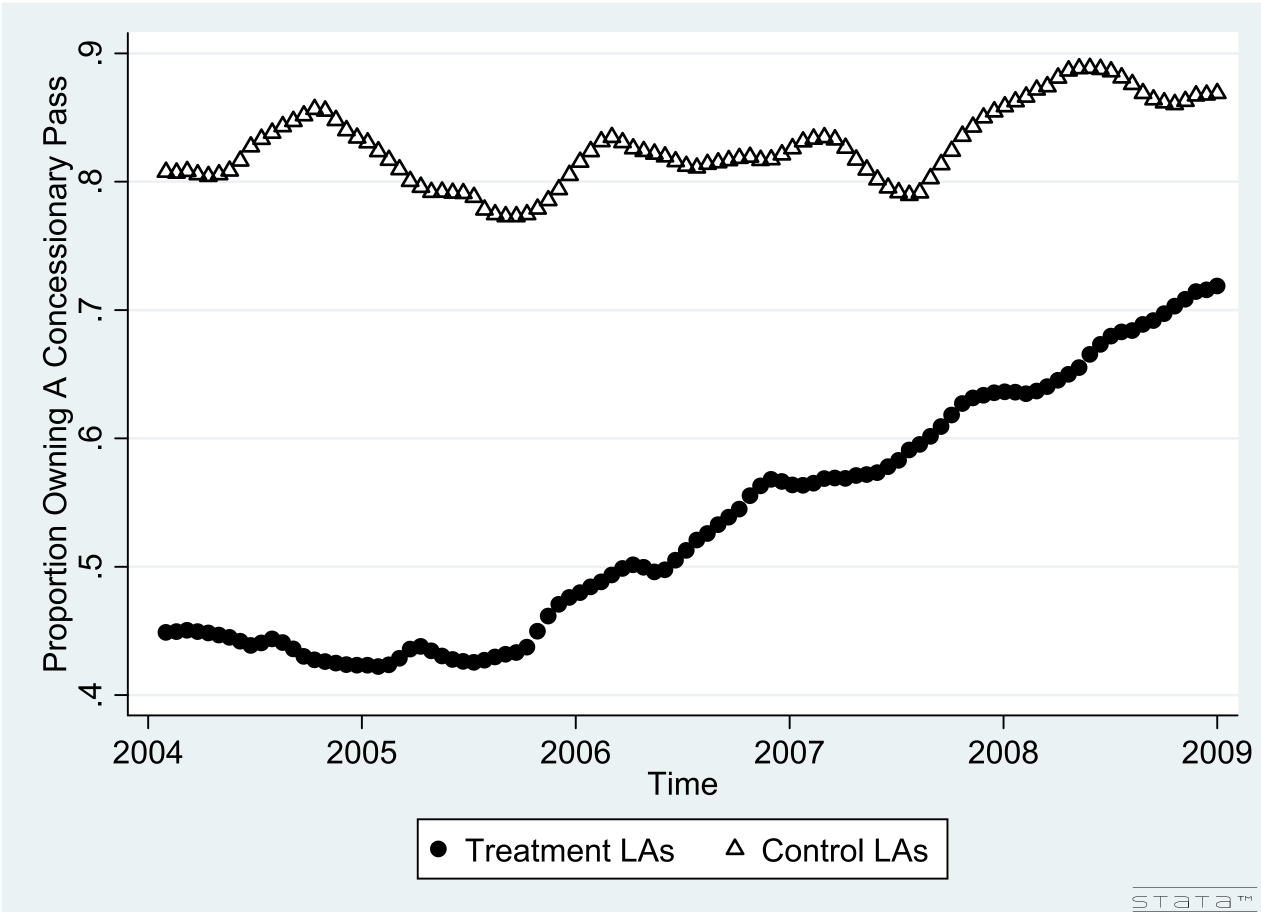
First, the reform did produce a substantive change in travel behaviour amongst the older population: pass ownership rose, recorded bus journeys increased at both the extensive and intensive margins of travel, and individuals reported a greater general frequency of bus use. In addition to the utility from trips received by bus users, further benefits stem from activities most directly related to travel: the APS suggests that days of "moderate walking" increased, which could help prevent and manage chronic disease, whilst also improving day to day engagement with the local community; ELSA results point towards perceived improvements in access to services, potentially reducing the burden on carers and maintaining independence for longer. Tentative welfare calculations suggest that total benefits do exceed the fiscal cost the reform, albeit with a large portion of the gains coming from reduced deadweight loss in the local bus market. However, in the absence of comparable studies on large scale interventions or policies, the magnitude of behavioural responses and any external gains are hard to benchmark. If national governments and international bodies wish to pursue an "active ageing or "healthy ageing" agenda, more research is needed to identify policies that should be prioritized, and to understand the mechanisms through which those policies might affect outcomes. (WHO, 2007, p. 20)

Second, although the reform does carry some substantive benefits for the older population, these gains should not be overplayed. The WHO claim that accessible transport is a critical component of active ageing as "being able to move about.....determines social and civic participation and access to community and health services". Cross-sectional correlations appear to support this claim, with bus users recording higher levels of social participation and well being. However, on the margin, the FBP policy has no effect on any measures of this type. The most positive interpretation of this result, or absence of results, is that to extent that public transport plays a role in promoting social inclusion price is not the crucial margin. A less optimistic, but perhaps more accurate, explanation is that the null effects of the reform serve as a reminder that cross-sectional correlations should not be used to inform policy; such correlations may be driven by a multitude of unobservables at both the individual and local level. Limited evidence of an impact upon direct measures of health is perhaps less surprising, given the possibility of time lags and the short post-reform period; nevertheless, the immediate effects seem small.

Third, as governments struggle bring budget deficits under control, universal benefits are under increased scrutiny. Universal provision of the FBP is justified on efficiency grounds if aggregate gain from correcting the market failures described in section 2, is greater than the additional costs. This could operate through small individual benefits for a large spectrum of the population, or improved gains amongst disadvantaged groups, whose response may depend on the behaviour of their richer peers (Cutler, 2004). NTS data indicates that the travel response did not vary by individual socioeconomic characteristics. Yet, ELSA data shows that improvements in access are concentrated amongst existing bus users, who are disproportionately disadvantaged. Moreover, the "no better off, no worse off" funding arrangements for the FBP Policy ensure that the implied distribution of public resources is far more progressive than for universal lump sum transfers, such as the Winter Fuel Payment, or subsidies for goods universally consumed, such as free television licenses for the over 75s. This paper does not address the relative cost effectiveness of means tested verses universal provision. However, the optimal eligibility criteria for behavioural interventions are a crucial issue for both future research and policy design.

In conclusion, the FBP policy does deliver benefits consistent with active ageing for those that choose to take up the concession. What is less clear is whether the reform represents the most effective use of public resources. Future reforms to promote active ageing should have a clearly defined target group and set of objectives, and an understanding of the mechanisms though which the those objectives could be achieved. In the absence of this rubric, it is very hard to prioritise reforms, exploit complementarities with existing systems and institutions, or to properly evaluate whether policies are cost-effective.

Figure 1: Pass Take Up: Proportion of Those Aged 60+ that Hold a Concessionary Pass, by quarter, NTS Jan 2004- Dec 2008 (Nadaraya-Watson Kernel Regression)

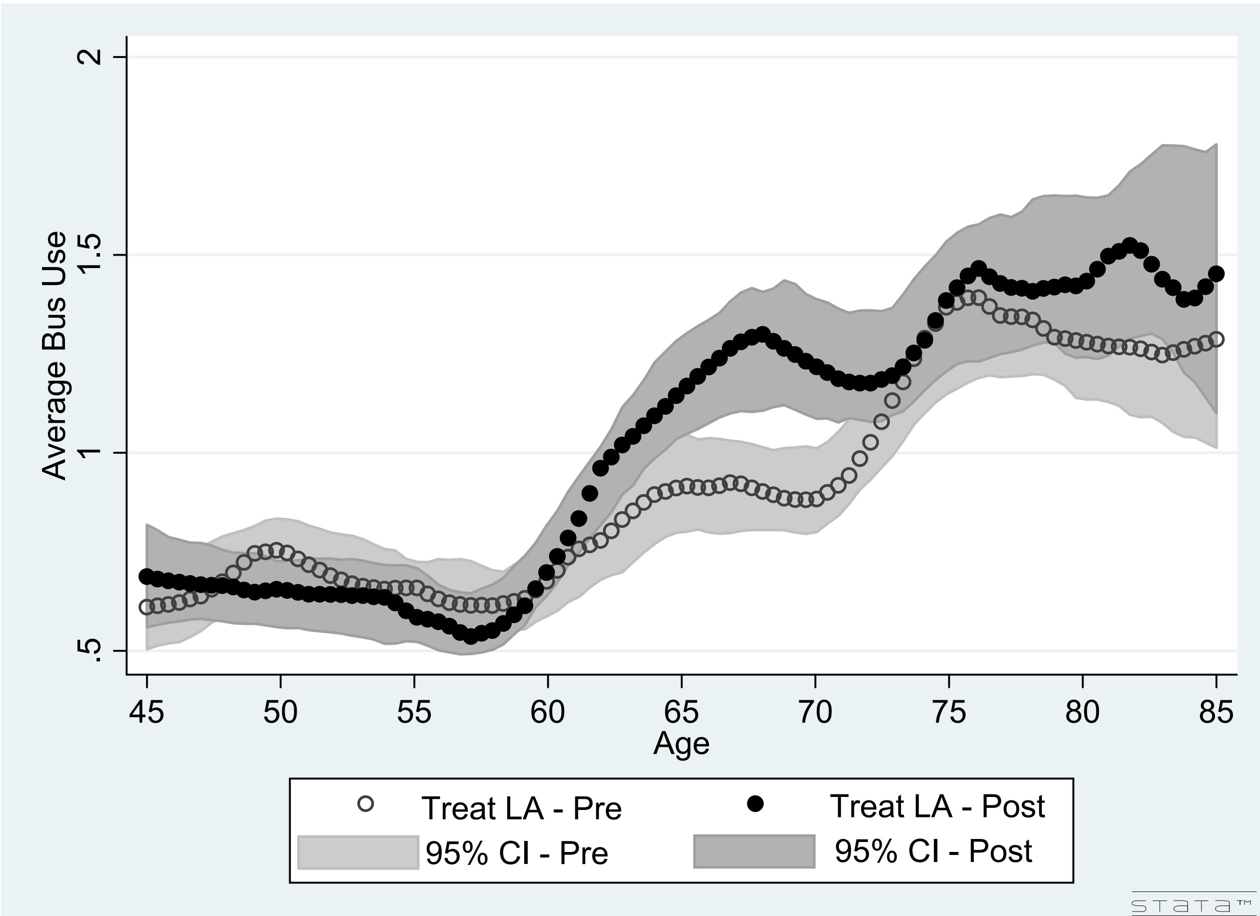



Notes: Univariate Nadaraya-Watson kernel regression of pass ownership by month, using an epanechnikov kernel with a bandwidth of 0.14 years. The sample includes only those aged 60 and over, who responded to the NTS between January 2004 and March 2008.

Table 1: Treatment and Control Group Definitions

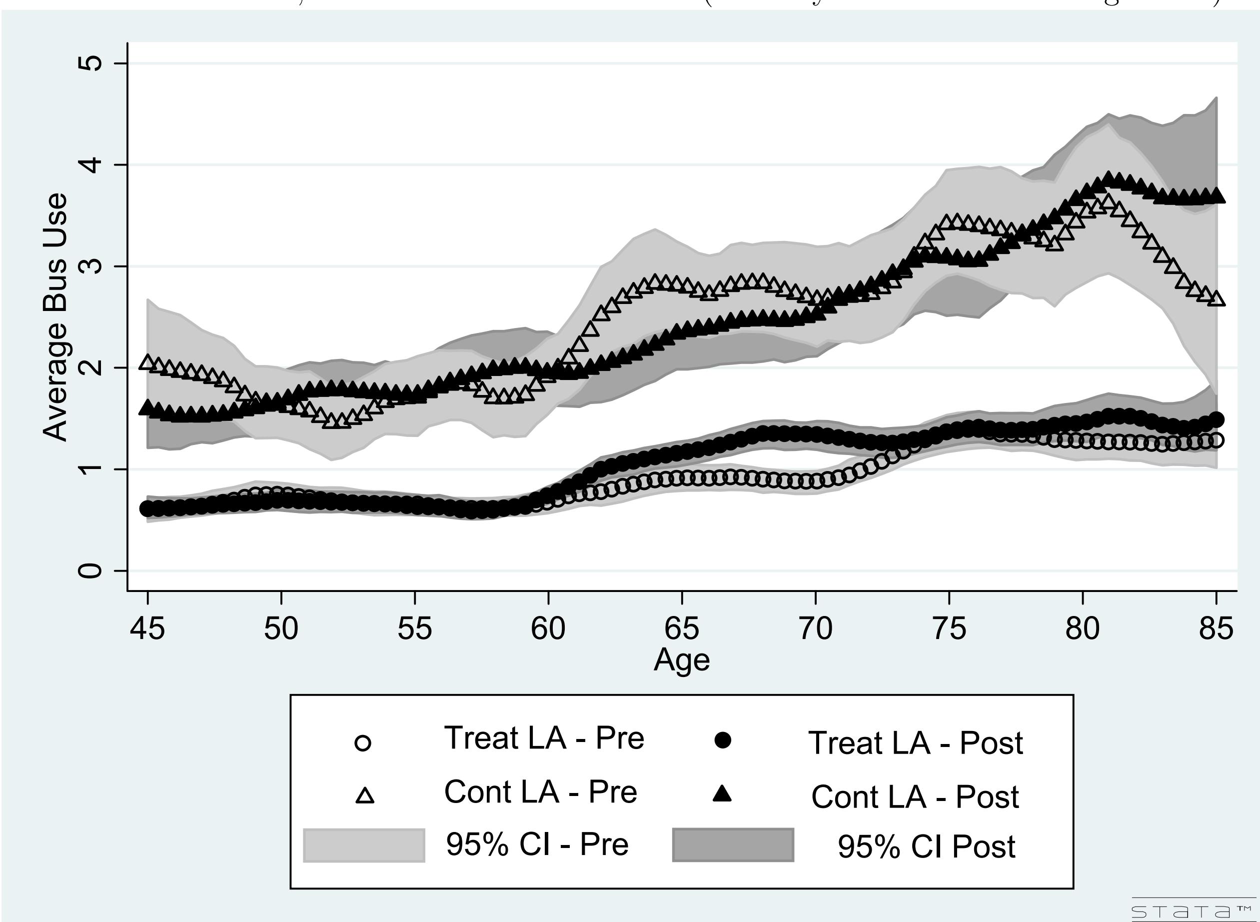
| | Pre-Existing Free Bus Travel Scheme | |
|---|---|---|
| Age | No (Treatment LA) | Yes (Control LA) |
| 60 and over | Treated | Not Treated<br>"geographic controls" |
| Under 60 | Not treated<br>"age controls" | Not Treated |

Figure 2: Mean Bus Journey Recorded in the NTS Travel diary, by Age and LA type, Pre and Post the FBP Reform, NTS Jan 2004- March 2008 (Nadaraya-Watson Kernel Regression)




Notes: Univariate Nadaraya-Watson kernel regression of weekly bus use by age, using an epanechnikov kernel with a bandwidth of 1.3 years. The shaded areas show 95 percent confidence intervals, calculated using bootstrapped standard errors. Those aged over 85 are excluded due to small sample size.

Figure 3: Mean Bus Journey Recorded in the NTS Travel diary, by Age and LA type, Pre and Post the FBP Reform, NTS Jan 2004- March 2008 (Nadaraya-Watson Kernel Regression)




Notes: Univariate Nadaraya-Watson kernel regression of weekly bus use by age, using an epanechnikov kernel with a bandwidth of 1.3 years. The shaded areas show 95 percent confidence intervals for the pre-reform period, calculated using bootstrapped standard errors. Those aged over 85 are excluded due to small sample size.

Figure 4: Demand for Bus Travel Amongst Pensioners

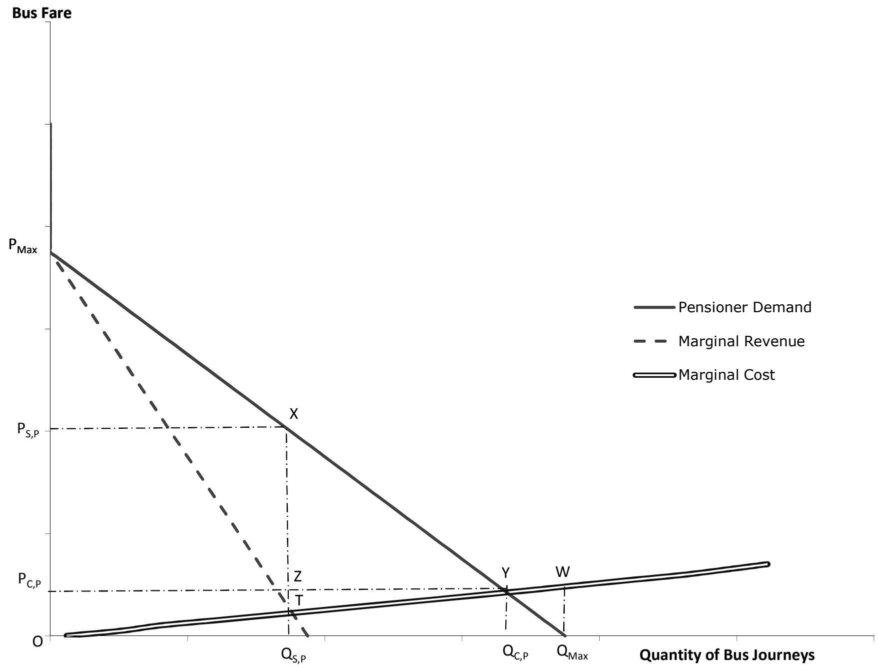



Table 2: Mean Value of Selected Travel Outcomes, By Treatment/Control Group, Prior to the Reform – National Travel Survey 2004-April 2006, standard deviations in brackets

| | Treatment LA | | Control LA | |
|---|---|---|---|---|
| | (1) "Treatment" | (2) "Age Cont" | (3) "Geo Cont" | (4) "Age/Geo Cont" |
| | Age 60+ | Age <60 | Age 60+ | Age <60 |
| Pass Holder | 0.445 | - | 0.818 | - |
| | (0.497) | | (0.388) | |
| Bus User | 0.216 | 0.135 | 0.473 | 0.273 |
| (Bus Journeys >=1) | (0.408) | (0.344) | (0.499) | (0.444) |
| No. Bus Journeys | 1.037 | 0.663 | 2.907 | 1.693 |
| | (2.623) | (2.318) | (4.219) | (3.745) |
| No. Car Journeys | 8.371 | 13.473 | 5.837 | 10.154 |
| | (10.428) | (11.857) | (9.283) | (10.970) |
| No. Journeys | 15.078 | 19.843 | 13.886 | 17.484 |
| | (9.468) | (10.311) | (8.919) | (9.567) |
| N | 6,750 | 5,772 | 1,354 | 1,453 |

Notes: National Travel Survey January 2004-March 2006. The sample includes those aged 45 and over, who live in England, and responded to the travel diary. Journeys are weighted to take reporting drop-off and non-response to the travel diary into account. Journey totals are per week.

Table 3: The FBP Reform, Concessionary Pass Ownership and Bus Travel, NTS Jan 2004-Dec 2008

| | Pass Owner | Bus Journeys - AMEs | | | Gen. Use |
|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) |
| | Pr(Q=1) | Ave (E(Q)) | Ext (Pr(Q>0)) | Int (E(Q)\|Q>0)) | (O−Probit) |
| $\text{PostFBP}_t$ x $\text{TreatLA}_l$ x $\text{EligAge}_i$ | | 0.335** | 0.0492** | 0.343** | 0.206** |
| | | [0.150] | [0.0219] | [0.154] | [0.0867] |
| $\text{PostFBP}_t$ x $\text{TreatLA}_l$ | 0.148*** | -0.0832 | -0.0122 | -0.0852 | -0.0602 |
| | [0.0205] | [0.126] | [0.0185] | [0.129] | [0.0796] |
| $\text{PostFBP}_t$ x $\text{EligAge}_{i\ it}$ | | -0.0738 | -0.0088 | -0.0524 | -0.0448 |
| | | [0.157] | [0.0208] | [0.125] | [0.0774] |
| $\text{PostFBP}_t$ | -0.109*** | -0.120 | -0.0176 | -0.123 | -0.0734 |
| | [0.0280] | [0.142] | [0.0209] | [0.146] | [0.0834] |
| Observations | 16395 | 29112 | 29112 | 29112 | 22544 |
| Psuedo R-Squared | 0.1646 | 0.0953 | 0.0953 | 0.0953 | 0.0767 |

Notes: *** denotes significance at 1%, ** at 5%, and * at 10% level. All samples are drawn from those aged 45 and over, living in England, who responded to the NTS travel diary between January 2004 and March 2008. Observations are at the diary respondent, or individual, level, and are weighted to account for non-response to the travel diary. Column 1 corresponds to a LPM specification, where the dependent variable is an indicator for pass ownership and the sample is restricted to those 60 and over. Columns 2-4 show results from a tobit regresion, where the dependent variable is recorded number of bus journeys. Journeys are weighted to account for recording drop off, as the diary week progresses. Reported estimates are AMEs on observed number of journey (uncondition on use), the probability of making at least one journey, and the number of journeys conditional upon making one journey, are shown in columns 2, 3 and 4 respectively. In column 5, the dependent variable is an categorical variable for the general frequency of bus use, and results are estimated using an ordered probit regression; reported results are ordered probit coefficients. Standard errors in all columns are heteroskedasicity robust and clustered at the local authority level. All specifications include county, year and month dummies, and a full set of individual and local authority controls. Individual or household controls include: a cubic in age, sex, top employment status, marital status, household structure, household income quintile, socio-economic group, tenure type, walking distance from a bus stop, and bus distance from a rail station, and imputed. Fixed LA controls include: the percentages of men unskilled, households with no car, population over 60, and commuting by mode. Time varying LA controls include: PSU and LA population density, quarterly unemployment, median male full time weekly wages (annual), and local authority transport related current expenditure (annual). Monthly unleaded petrol and diesel prices are given by month, at the national level.

Table 4: Average Marginal Effects of the FBP Reform upon Reported Travel, by Alternative Modes, and Total Journeys, NTS Jan 2004-Dec 2008

| | Recorded Journeys by Mode, E(Q) | | | | | Total Journeys | |
|---|---|---|---|---|---|---|---|
| | (1) Bus Use | (2) Car Driver | (3) Car Pass | (4) Walking | (5) Rail | (6) All | (6) All ex. Bus |
| $PostFBP_t$ x $TreatLA_l$ x $EligAge_i$ | 0.343** | -0.174 | 0.380 | 0.0946 | -0.0370 | 0.422 | 0.108 |
| | [0.154] | [0.712] | [0.277] | [0.178] | [0.0517] | [0.658] | [0.698] |
| $PostFBP_t$ x $EligAge_i$ | -0.0524 | 0.139 | -0.354 | -0.124 | 0.0091 | -0.213 | -0.168 |
| | [0.125] | [0.663] | [0.259] | [0.161] | [0.0417] | [0.602] | [0.641] |
| $TreatLA_l$ x $PostFBP_t$ | -0.0852 | -0.00554 | -0.160 | -0.0163 | 0.0182** | -1.210*** | -0.443 |
| | [0.129] | [0.553] | [0.211] | [0.130] | [0.0370] | [0.443] | [0.502] |
| $PostFBP_t$ | -0.123 | 0.647 | 0.284 | -0.121 | -0.108** | 0.717 | 0.890 |
| | [0.146] | [0.638] | [0.237] | [0.167] | [0.0454] | [0.604] | [0.688] |
| Observations | 29112 | 29112 | 29112 | 29112 | 29112 | 29112 | 29112 |
| R-squared | 0.0953 | 0.0584 | 0.0535 | 0.0104 | 0.0839 | 0.137 | 0.188 |

Notes: *** denotes significance at 1%, ** at 5%, and * at 10% level. All samples are drawn from those aged 45 and over, living in England, who responded to the NTS travel diary between January 2004 and March 2008. Observations are at the diary respondent, or individual, level, and are weighted to account for non-response to the travel diary. Each column refers to a separate regression. Columns 1 to 5 use Tobit specifications, where the dependent variables are journeys recorded in the travel diary by alternative modes. Columns 6 and 7 use OLS; dependent variables are total recorded journeys by all modes in column 6, and total journeys excluding bus journeys in column 7. Results reported are AMEs on observed journeys (unconditional on mode use). All journeys are weighted to account for recording drop off, and standard errors are heteroskedasicity robust and clustered at the local authority level. All specifications include county, year and month dummies, plus a full set of individual and local authority controls. Individual or household controls include: a cubic in age, sex, top employment status, marital status, household structure, household income quintile, socio-economic group, tenure type, walking distance from a bus stop, and bus distance from a rail station, and imputed. Fixed LA controls include: the percentages of men unskilled, households with no car, population over 60, and commuting by mode. Time varying LA controls include: PSU and LA population density, quarterly unemployment, median male full time weekly wages (annual), and local authority transport related current expenditure (annual). Monthly unleaded petrol and diesel prices are given by month, at the national level.

Table 5: Average Marginal Effect of the FBP Reform upon Reported Days Walking At Moderate Pace for 30 minutes, APS waves 1 and 2

| | DDD | | Age DD, Treatment LAs | |
|---|---|---|---|---|
| | (1) All | (2) HP Areas | (3) All | (4) HP Areas |
| $APS2_t$ x $TreatLA_l$ x $I(Age\ 55\text{-}64)_i$ | -0.154 | 0.154 | | |
| | [0.261] | [0.334] | | |
| $APS2_t$ x $TreatLA_l$ x $I(Age\ 65\text{-}74)_i$ | 0.527* | 0.892** | | |
| | [0.316] | [0.438] | | |
| $APS2_t$ x $TreatLA_l$ x $I(Age75+)_i$ | 0.552 | 1.143* | | |
| | [0.440] | [0.627] | | |
| $APS2_t$ x $I(Age\ 55\text{-}64)_i$ | 0.228 | 0.197 | 0.0736 | 0.197 |
| | [0.244] | [0.258] | [0.0916] | [0.227] |
| $APS2_t$ x $I(Age\ 65\text{-}74)_i$ | -0.236 | -0.213 | 0.289*** | 0.576** |
| | [0.297] | [0.301] | [0.109] | [0.234] |
| $APS2_t$ x $I(Age75+)_i$ | -0.379 | -0.365 | 0.172 | 0.646** |
| | [1.824] | [0.416] | [0.155] | [0.318] |
| $APS2_t$ x $TreatLA_l$ | -0.125 | -0.435** | | |
| | [0.171] | [0.219] | | |
| $APS2_t$ | 0.156 | 0.103 | 0.0330 | -0.305** |
| | [0.159] | [0.165] | [0.0640] | [0.136] |
| Individuals | 155177 | 42479 | 136507 | 25690 |
| Psuedo R-Squared | 0.0269 | 0.0273 | 0.0268 | 0.0259 |

Notes: *** denotes significance at 1%, ** at 5%, and * at 10% level. All samples are drawn from APS respondents aged 45 and over, who responded to the APS between October 2005 and April 2006 (APS1) or October 2007 and April 2008 (APS2). Observations are at the APS respondent level. Each column represents a separate Tobit specification, where the dependent variable is the number of days in the past 4 weeks the respondent reported walking moderately for 30 minutes. Results reported are AMEs on observed journeys (unconditional upon journeys recorded). Column 1 contains the whole sample. Column 2 restricts the sample to LAs with population density at least 14 persons/hectare. Column 3 includes only those in Treatment LAs, and column 4 only those in Control LAs. Individual/household level controls include sex, age band, terminal age of education, household income decile, housing tenure, number of adults, and county dummies. Local authority controls include an index of multiple deprivation, LA population density, and percentages of LA households with no car, working age men unskilled, and population over 60.

Table 6: The FBP Reform and the Probability of Reporting Very Easy Access to Post Offices and GPs: ELSA 2002, 2004 and 2008, Treatment LAs

| | Post Office | | | | GP/Primary Care | | | |
|---|---|---|---|---|---|---|---|---|
| | (1) Ave | (2) Age Band | (3) Bus User 04 | (4) Non User 04 | (5) Ave | (6) Age Band | (7) Bus User 04 | (8) Non User 04 |
| $\text{PostFBP}_t$ x $\text{EligAge}_{it}$ | 0.0610*** | | | | 0.0394* | | | |
| | (0.0220) | | | | (0.0220) | | | |
| $\text{PostFBP}_t$ x $\text{I(Age 60-64)}_{it}$ | | 0.0622** | 0.183*** | 0.0136 | | 0.0315 | 0.0924* | 0.0131 |
| | | (0.0279) | (0.0501) | (0.0336) | | (0.0281) | (0.0506) | (0.0338) |
| $\text{PostFBP}_t$ x $\text{I(Age 65-69)}_{it}$ | | 0.0486** | 0.141*** | 0.00789 | | 0.0240 | 0.0441 | 0.0219 |
| | | (0.0245) | (0.0428) | (0.0300) | | (0.0245) | (0.0430) | (0.0300) |
| $\text{PostFBP}_t$ x $\text{I(Age 75+)}_{it}$ | | 0.0608** | 0.186*** | -0.00730 | | 0.0668** | 0.146*** | 0.0240 |
| | | (0.0300) | (0.0507) | (0.0377) | | (0.0303) | (0.0514) | (0.0380) |
| $\text{I(2004)}_{it}$ | -0.0648*** | -0.0640*** | -0.0709*** | -0.0605*** | -0.0521*** | -0.0511*** | -0.0568*** | -0.0494*** |
| | (0.0123) | (0.0123) | (0.0212) | (0.0151) | (0.0122) | (0.0122) | (0.0212) | (0.0150) |
| $\text{I(2008)}_{it}$ / $\text{PostFBP}_t$ | -0.131*** | -0.125*** | -0.145** | -0.120*** | -0.133*** | -0.127*** | -0.0869 | -0.157*** |
| | (0.0338) | (0.0345) | (0.0602) | (0.0422) | (0.0338) | (0.0345) | (0.0605) | (0.0422) |
| Observations | 10218 | 10218 | 3639 | 6579 | 10218 | 10218 | 3639 | 6579 |
| No of Individuals | 3406 | 3406 | 1213 | 2193 | 3406 | 3406 | 1213 | 2193 |

Notes: *** denotes significance at 1%, ** at 5%, and * at 10% level. All samples are drawn from ELSA cohort members in Treatment LAs who responded to access questions in 2002,2004, and 2008. Observations are at the cohort member year level. Each column refers to a separate LPM specification, with random effects and heteroskedasticity robust standard errors. The dependent variables are indicators for whether the individual reported access to post offices (columns 1-4) and GPs (columns 5-8) was very easy. Reported results are marginal effects of the reform the probability of reporting very easy access. Columns 1, 2, 5, and 6 use the whole sample. Columns 3 and 7 contains those sample members who reported using public transport at least "sometimes" in 2004. In columns 4 and 8, the sample includes those who used public transport rarely or never in 2004. Individual level controls include a cubic in age, and income quintile (measured in 2006), self rated health in 2004, whether the respondent has children alive, and number of grandchildren. Fixed LA controls include: population density the percentages of men unskilled, households with no car, population over 60, and commuting by mode. Time varying LA controls include: median male full time weekly wages, and local authority transport related current expenditure and average diesel and unleaded prices (national)

Table 7: Key Parameters for Welfare Calculations

| Parameter | Corresp to Fig 4 | Source | Value |
|---|---|---|---|
| Pre-Reform Average Annual Journeys | $Q_{S,P}$ | Author's calculations using NTS (Jan 2004 and March 2006) | 54 |
| Pre-Reform Bus Fare (2004 Prices, £) | $P_{S,P}$ | Half the Adult bus fare, Imputed using a hedonic regression and recorded bus fares for those aged 25 to 50. | 0.63 |
| SR price elasticity of demand | – | Estimate from section 5. | -0.3 |
| Pre-Reform Fiscal Cost/Person/Year (2004 Prices, £) | – | Author's calculations using Revenue Outturn \$-\$ Highways, Roads and Transport services (RO2); Dept for Communities and Local Governments. | 22 |
| Post- Reform Fiscal Cost/Person/Year (2004 Prices, £) | – | Author's calculations using Revenue Outturn \$-\$ Highways, Roads and Transport services (RO2); Dept for Communities and Local Governments. | 46 |

Notes: All figures are for Treatment LAs. All fares and costs are in 2004 prices, calculated using the the Retail Price Index excluding housing cost.

# A A Model of Transport Behaviour

Individual $i$ has T units of time per week. For each time-unit, $t$, $i$ generates utility from choosing amongst the $a = 1......A$ time use alternatives, or "activities". These $A$ alternatives are comprised of one option of home consumption ($HC$), and multiple activities outside the home (**OC**), each of which is defined by a mode/destination combination. For simplicity, it is assumed that there are three modes and three destinations, giving the consumer ten possible options. An individual makes a journey when they choose an activity outside the home, and all activities take precisely one unit of time. The utility derived by individual $i$, in time unit $t$, and for activity $a$, $u_{ita}$, is as follows:

$$u_{ita} = Act'_{ita}\mu_{it} + \varepsilon_{ija} \tag{3}$$

$$\mu_{it} = \tilde{\mu} + D'_i\eta + \Omega e_{it} \tag{4}$$

where $Act_{ita}$ is a vector of observed characteristics pertaining to the alternative and the decision maker, and $\mu_{it}$ a vector of individual specific taste parameters; $\mu_{it}$, is composed of a portion common to all, $\tilde{\mu}$, and a portion that depends upon individual characteristics, $D'_i\eta$. Lastly, $\Omega$ is a diagonal matrix, whose elements are standard deviations, and $e_{it}$ is a vector of independent standard normal deviates.

An individual's total weekly utility is determined by the sum of the chosen activities, $u^*_{ita}$, across $t$, and a composite commodity of all other goods, $z$.

$$U_i = \sum_{t=1}^{T} u^*_{ita}(Act^*_{iat}, D_i) + \alpha_i z \tag{5}$$

Weekly utility is assumed to be additively separable across $T$ and linear in all arguments. The individual's objective is to maximise weekly utility subject to her budget constraint:

$$\sum_{t=1}^{T_i} p^*_{at} + z \leq y_i \tag{6}$$

where $p^*_{at}$ is the price of activity of the chosen activity on occasion $t$, and $y_i$ is the individual's weekly income. The price of $HC$ is normalised to 1, with $p_{at} > 1$, where $a \neq HC$. As the budget constraint binds, the consumer's problem becomes:

$$U_i = \sum_{t=1}^{T} u^*_{ita}(Act^*_{iat}, D_i) - \sum_{t=1}^{T_i} p^*_{at} + y_i \tag{7}$$

Given additive separability and linearity, we can treat each decision independently. The indirect utility of activity $a$, for individual $i$, is therefore equal to the following (Nevo, 2000):

$$v_{ita} = \alpha_i(y_i - p_{at}) + Act'_{ita}\mu_{it} + \varepsilon_{ita} \tag{8}$$

where $\alpha_i$ is an individual specific scalar, which represents the consumers marginal utility of income. Dropping the $t$ subscript for simplicity, for any given $t$, activity $a$ is chosen if $v_{ia} = max(v_{i1} \ldots v_{iA})$. The specific specification for indirect utility means the income effects are small and constant within individuals, but can vary across individuals through $\alpha_i$.

# B National Travel Survey

## B.1 Baseline Bus Travel Results - Specification Tests

Table A.1 presents a series of specification checks, which test the robustness of results in section 5.21. The dependent variable in all columns is number of bus journeys recorded in the travel diary. Column 1 present the baseline DDD specification, with standard errors clustered at the local authority level (360 clusters). The specification in column 2 is identical, but with standard errors clustered at the county level (50 clusters). Reducing the number of clusters is more conservative, and allows for any correlation in errors brought about by pre-reform concessionary schemes operating at the county level. The change in clustering has a minimal impact on the standard errors, and thus has no effect on the statistical significance of the estimated policy effect.

Column 3 adds interactions between county and year indicators. This allows for county specific changes in travel incentives contiguous with the reform, such as changes in bus fares. The estimated policy effect is slightly larger, but statistically identical to the baseline result in column 1. In column 4, the sample is restricted to high density population areas (the top two quintiles of the sample, corresponding to population densities of 14 persons/hectare and above). This acts to make Treatment and Control LAs more similar on observable characteristics, which could reduce the potential for confounding differential trends. The estimated coefficient is more than double that in column 1, but the difference is not statistically significant. However, the specification is unable to disentangle whether the larger coefficient is a result of the removal of a confounding differential trend, or a larger effect in high density Treatment LAs.

Column 5 introduces an alternative placebo policy $AltPol_t$, which enacts the FBP policy in April 2005, a year earlier than the real reform. Conditional upon the real reform, $AltPol_t$ and its interactions should have no impact upon travel behaviour. Results confirm that the alternative policy has no effect upon bus journeys, and does not (statistically) change the estimated effects of the true FBP reform.

Overall, Table A.1 indicates that results for total bus journeys are robust to a range of specification tests, and provides no evidence of pre-existing or contemporaneous differential time trends.

## B.2 Heterogeneity in Travel Response by Age and Population Density

Table A.2 considers heterogeneity in the effects of the reform by age and population density. In Column 1, the $EligAge_i$ dummy in the baseline DDD specification is replaced by four age categories (45-59, 60-64, 65-74, 75+, with the 45-59 age dummy omitted). Results indicate that the policy is associated with an increase in bus travel statistically significant at the five percent level for those aged 65-74, and the ten percent level for those aged 60-64. However, differences in AMEs across eligible age groups are not statistically significant. Column 2 restricts the sample to those living in the top two quintiles of the LA population density distribution, again corresponding to at least 14 persons per hectare (HP sample). Estimated effects of the policy are larger in magnitude than those in column 1 and statistically significant at the five percent level for those aged under 75. However, the difference between columns

1 and 2 are not statistically significant.

Columns 3-5 estimate the effects of the reform using age DD specifications, with samples limited to those in Treatment LAs. $PostFBP_t$/age group interactions in columns 1 and 2 lack statistical significance and are negative for those under 75. If those negative coefficients for those aged 60+ in control LAs reflect an underlying national trend, age DD specifications may underestimate the effects of the reform. However, removing the noisy Control LA data substantially improves the precision of reform estimates. In column 3, which includes all Treatment LAs, the reform has a positive effect upon all eligible age groups, with AMEs significant at the one percent level. Columns 4 and 5 split the sample into high (HP) and low (LP) population density areas. Estimated AMEs indicate that policy effects were positive and significant at the one percent level for all eligible age groups in the HP sample, whilst in the LP sample effects are significant only at the ten percent level for those aged 65-75. AMEs in columns 4 and 5 are statistically different from each other at the one percent level.

# C ELSA Sample

Table A.3 shows the sample size in each of the four treatment/control groups. As the sample is not refreshed, the proportion of cohort members aged 60 and over increases by 50 percent between 2002 and 2008. In 2004, 31.6 percent of the cohort was in the age control group, compared to 9.7 percent in the geographic controls; by 2008, the gap had closed substantially to 16.3 percent in the age controls and 12.4 percent in the geographic controls. By 2008, there are only 162 cohort members in the "Age/Geographic" control group. Sample sizes in the self-response questionnaire are even smaller. There are 4,306 cohort members who answered the access questions in all three waves; in 2008, 2,939 were in the treated group, 757 were age controls, 493 geographic controls, and 117 age/geographic controls.

Table A.1: Average Marginal Effects of the FBP Reform Upon Recorded Bus Journeys - Specification Checks, NTS Jan 2004-Dec 2008

| | Recorded Bus Journeys, E(Q) | | | | |
|---|---|---|---|---|---|
| | (1) Baseline | (2) County SE | (3) County TT | (4) HP Areas | (5) Alt Pol |
| $\text{PostFBP}_t$ x $\text{TreatLA}_l$ x $\text{EligAge}_i$ | 0.343** | 0.343** | 0.358** | 0.828*** | 0.362** |
| | [0.154] | [0.137] | [0.148] | [0.255] | [0.159] |
| $\text{PostFBP}_t$ x $\text{EligAge}_i$ | -0.0524 | -0.0524 | -0.0631 | -0.0466 | -0.0570 |
| | [0.125] | [0.126] | [0.131] | [0.205] | [0.135] |
| $\text{PostFBP}_t$ x $\text{TreatLA}_l$ | -0.0852 | -0.0852 | -0.0888 | -0.394 | -0.136 |
| | [0.129] | [0.135] | [0.196] | [0.223] | [0.153] |
| $\text{PostFBP}_t$ | -0.123 | -0.123 | -0.111 | -0.135 | -0.115 |
| | [0.142] | [0.108] | [0.183] | [0.251] | [0157] |
| $\text{AltPol}_t$ x $\text{TreatLA}_l$ x $\text{EligAge}_i$ | | | | | -0.0478 |
| | | | | | [0.0899] |
| $\text{AltPol}_t$ x $\text{EligAge}_i$ | | | | | -0.0570 |
| | | | | | [0.135] |
| $\text{TreatLA}_l$ x $\text{AltPol}_t$ | | | | | 0.0926 |
| | | | | | [0.111] |
| $\text{AltPol}_t$ | | | | | -0.123 |
| | | | | | [0.118] |
| LA Clust. SE (360) | Yes | No | Yes | Yes | Yes |
| County Clust. SE (50) | No | Yes | No | No | No |
| I(County)*Year | No | No | Yes | No | No |
| Observations | 29112 | 29112 | 29112 | 11519 | 29112 |
| Pseudo R-Squared | 0.0954 | 0.0954 | 0.0995 | 0.0688 | 0.0953 |

Notes: *** denotes significance at 1%, ** at 5%, and * at 10% level. All samples are drawn from those aged 45 and over, living in England, who responded to the NTS travel diary between January 2004 and March 2008. Observations are at the diary respondent, or individual, level. Respondents are weighted to account for non-response to the travel diary. Each specification refers to a separate Tobit regression, where the dependent variables are bus journeys recorded in the travel diary. Journey records are weighted to account for recording drop off, as the diary week progresses. Results reported are AMEs on observed journeys (unconditional on bus use). Columns 1,2,3, and 5 contain the whole sample. Column 4 restricts the sample to the top two quintiles of the LA population density distribution (28 persons/hectare and above). In columns 1, 3, 4 and 5, Standard errors are heteroskedasicity robust and clustered at the local authority level. In column 2 standard errors are heteroskedasicity robust and clustered at the county level. AltPolicy is equal to one in all periods after and including April 2005. All specifications include county, year and month dummies, plus a full set of individual and local authority controls. Individual or household controls include: a cubic in age, sex, top employment status, marital status, household structure, household income quintile, socio-economic group, tenure type, walking distance from a bus stop, and bus distance from a rail station, and imputed. Fixed LA controls include: percentages of men unskilled, households with no car, population over 60, and commuting by mode. Time varying LA controls include: PSU and LA population density, quarterly unemployment, median male full time weekly wages (annual), and local authority transport related current expenditure (annual). Monthly unleaded petrol and diesel prices are given by month, at the national level.

Table A.2: Average Marginal Effects of the FBP Reform upon Recorded Bus Use, by Age and Population Density, NTS Jan 2004-Dec 2008

| | DDD, E(Q) | | Age DD (Treat LAs), E(Q) | | |
|---|---|---|---|---|---|
| | (1) All | (2) HP | (3) All | (4) HP | (5) LP |
| $\text{PostFBP}_t$ x $\text{TreatLA}_l$ x I(Age 60-64)$_i$ | 0.376* | 1.026*** | | | |
| | [0.227] | [0.380] | | | |
| $\text{PostFBP}_t$ x $\text{TreatLA}_l$ x I(Age 65-74)$_i$ | 0.440** | 0.793** | | | |
| | [0.194] | [0.336] | | | |
| $\text{PostFBP}_t$ x $\text{TreatLA}_l$ x I(Age75+)$_i$ | 0.142 | 0.623* | | | |
| | [0.180] | [0.326] | | | |
| $\text{PostFBP}_t$ x I(Age 60-64)$_i$ | -0.100 | -0.563 | 0.228*** | 0.739*** | 0.0525 |
| | [0.203] | [0.919] | [0.0856] | [0.200] | [0.0845] |
| $\text{PostFBP}_t$ x I(Age 65-74)$_i$ | -0.137 | -0.423 | 0.249*** | 0.575*** | 0.128* |
| | [0.176] | [0.862] | [0.0674] | [0.160] | [0.0697] |
| $\text{PostFBP}_t$ x I(Age75+)$_i$ | 0.0985 | 0.691 | 0.192*** | 0.692*** | 0.0311 |
| | [0.157] | [0.723] | [0.0739] | [0.197] | [0.0670] |
| I($\text{PostFBP}_t$) x $\text{TreatLA}_l$ | -0.0846 | -0.393 | | | |
| | [0.129] | [0.226] | | | |
| I($\text{PostFBP}_t$) | -0.121 | -0.141 | -0.166* | -0.469* | -0.0647 |
| | [0.145] | [0.254] | [0.0978] | [0.263] | [0.0974] |
| Observations | 29112 | 11519 | 23631 | 6528 | 17103 |
| Psuedo R-Squared | 0.0948 | 0.0684 | 0.0917 | 0.0735 | 0.0885 |

Notes: *** denotes significance at 1%, ** at 5%, and * at 10% level. All samples are drawn from those aged 45 and over, living in England, who responded to the NTS travel diary between January 2004 and March 2008. Each column refers to a separate Tobit specification, where the dependent variables are bus journeys recorded in the travel diary. Diary responses are weighted to take non-response into account. Journey records are weighted to account for recording drop off, as the diary week progresses. Results reported are average marginal effects on observed journeys (unconditional on bus use). Column 1 contains the whole sample. Column 2 restricts the sample to the top quintiles of the LA population density distribution (HP). Column 3 contains Treatment LAs. Column 4 contains Treatment LAs in HP areas. Column 5 contains only Treatment LAs. Standard errors are heteroskedasicity robust and clustered at the local authority level. All specifications include county, year and month dummies, plus a full set of individual and local authority controls. Individual or household controls include: a cubic in age, sex, top employment status, marital status, household structure, household income quintile, socio-economic group, tenure type, walking distance from a bus stop, and bus distance from a rail station, and imputed. Fixed LA controls include: the percentages of men unskilled, households with no car, population over 60, and commuting by mode. Time varying LA controls include: PSU and LA population density, quarterly unemployment, median male full time weekly wages (annual), and local authority transport related current expenditure (annual). Monthly unleaded petrol and diesel prices are given by month, at the national level.

Table A.3: ELSA Sample present in waves 1-4, by Year and Treatment/Control group (% of within year sample in brackets)

| | 2002 | 2004 | 2006 | 2008 |
|---|---|---|---|---|
| (1) Treated | 2,876 | 3,311 | 3,700 | 4,255 |
| (Aged 60+, in Treatment LA) | (46.39) | (53.41) | (59.68) | (68.64) |
| (2) Age Controls | 2,391 | 1,958 | 1,571 | 1,013 |
| (Aged <60, in Treatment LA) | (38.57) | (31.58) | (25.35) | (16.34) |
| (3) Geographic Controls | 505 | 599 | 658 | 769 |
| (Aged 60+, in Control LA) | (8.14) | (9.68) | (10.62) | (12.41) |
| (4) Age/Geographic Controls | 427 | 331 | 270 | 162 |
| (Aged <60, in Control LA) | (6.9) | (5.33) | (4.35) | (2.61) |
| Total | 6,199 | 6,199 | 6,199 | 6,199 |
| | (100) | (100) | (100) | (100) |

Author's calculations using ELSA waves 1-4

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