

Where to park? A behavioural comparison of bus Park and Ride and city centre car park usage in Bath, UK

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Abstract

Integrating car parking facilities with public transport in Park and Ride (P&R) facilities has the potential to shorten car trips, contributing to more sustainable mobility. There is an ongoing debate about the actual effects of P&R on the transport system at the subregional level. A key issue is the relative attractiveness of city centre car parks (CCCP), P&R and public transport. The paper presents the findings of a comparative empirical case-study based on a field survey of CCCP and P&R users conducted in the city of Bath, UK. Spatial and statistical analyses are applied. Radial distance to parking, availability of P&R sites in the direction of travel, gender, age, income and party-size are found to be important factors in a binary logistic regression model, explaining the revealed-preference of parking type. Stated analysis of foregone parking alternatives suggests more use of public transport and walking/cycling would likely occur without first-best parking alternatives. The policy implications and possible planning alternatives to P&R at the urban fringes for achieving greater sustainability goals are also discussed.

Keywords

Transport policy; Park and Ride; parking; sustainable mobility; travel behaviour; public transport

1 Introduction

Park and Ride (P&R) has been widely adopted in developed countries in the last 20 years. In its most common form, P&R involves a car park adjacent to an intermodal transfer point which allows a traveller to change from car to public transport - commonly bus or rail - for the remainder

of the journey. P&R comes in a variety of guises and formats, ranging from more to less formal arrangements (Parkhurst & Richardson, 2002). Mingardo (2013) identifies three categories of P&R sites based on urban proximity and location:

- Remote P&R – These sites aim to intercept car drivers near the origin of their trips, and are usually located near users' homes in suburban locations.
- Peripheral P&R – The model typical to the UK and US, these sites aim to intercept drivers for the final leg of their trip, normally from the urban fringe into the urban centre; hence these sites are usually located on the urban periphery.
- Local P&R – These sites aim to intercept drivers at a number of points along their routes, with smaller distributed sites arrayed along main transport corridors. This format closely resembles the concept of 'Link and Ride' (Parkhurst, 2000a).

Bos (2004) suggests a number of factors which might contribute to creating a high-patronage P&R scheme: an optimally organised and complete network of P&R sites; a compact urban area; the development of incidental services and facilities at P&R sites; readily-available travel information; and strong, recognisable branding.

In the UK, the term P&R has generally become synonymous with bus-based systems (bus P&R), with parking lots usually located in the urban periphery (i.e. Mingardo's 2nd category above) providing a relatively fast and cheap connection to urban centres. Parking at rail stations is generally not marketed as P&R and often provides a long-range journey function, notably for commuting to central London. In contrast, in the Netherlands, as well as in other European countries, P&R promoted for a local and regional function is more commonly found on light and heavy rail lines.

The UK was one of the countries that pioneered the use of bus-based P&R in the early 1970s. Since then there has been substantial investment nationally – with P&R becoming an important feature of many local transport policies. By 2000 there were around 70 sites in operation (Parkhurst and Richardson, 2002) and by 2007 over 130 operating in Great Britain; together serving approximately 60 towns and cities across the country. Overall, this capacity is estimated to provide 70,000 parking spaces and to utilise more than 400 buses daily. The most recent national census of P&R capacity found it was accounting for around 46 million passenger journeys and generating revenues of £40m annually (TAS Partnership, 2007).

The focus of the present paper is to examine travel behaviour with respect to the interaction between supply and demand for both conventional city centre parking (CCCP) and bus-based P&R services for travel into the historic city centre of Bath, southwest England. The paper contributes to the P&R debate through an empirical spatial analysis of the parking choices of Bath city centre visitors, providing a novel analysis of the similarities and differences between city centre car park (CCCP) users and P&R users. The analysis examines the extent to which P&R users and CCCP users are part of the same mobility group, distinguished only by their mode choice and consequent travel behaviour in the final leg of their trip. Through understanding which users choose the P&R services and which choose to park in the city centre, the differing travel behaviours and their motivations can be elucidated. Additionally, new insights into improving sustainable demand management strategies are raised, with a view to informing local policymakers and transport providers. The paper contributes to these goals using Bath as a case study for examining the social and geographical attributes of P&R users and CCCP users, and using those attributes to explain motorists' motivations to use (or not use) P&R.

The rest of the paper is organised in the following manner: Section 2 introduces the debates in the scientific literature surrounding the traffic effects of bus P&R, which are then placed in the wider economic and parking policy context. Section 3 outlines the geographic and policy

context of the Bath case-study. Section 4 describes the methodology employed in data collection and subsequent analysis procedure. Section 5 presents the results of the analysis whilst the final discussion (Section 6) considers the policy implication for Bath and integrated parking and public transport strategy more generally.

2 Park and Ride: Motivations and policy effectiveness

Over the past two decades there has been an on-going academic debate about the real benefits of bus P&R for achieving sustainable mobility goals, including car traffic and emissions reduction. Bus P&R initially developed in the UK as a specialist solution for historic cities, but later captured wider central government and local authority interest as a means of addressing capacity limitations on local infrastructure in a wider range of settlement types (Meek, 2008). In the later 1990s the UK government widened the potential role seen for P&R to include a broader range of issues central to its transport policies – mainly in relation to sustainability and modal integration (Meek et al., 2010). This explicit support for P&R at the national policy level contributed to P&R acquiring an enduring, positive image in the perceptions of local policymakers as a highly effective method of reducing traffic congestion and air pollution in urban cores, whilst simultaneously being seen to raise the profile of other public transport schemes (DETR, 2000; Meek et al., 2010). More recently, however, there are indications that local policymakers and practitioners across Europe are becoming more cautious about the direct traffic reduction benefits of P&R investment (Dijk et al., 2013).

A growing body of empirical evidence – gathered by a number of studies into the actual traffic impacts of P&R schemes and their wider contribution to sustainability – has identified mixed outcomes. A number of inefficiencies with P&R have been demonstrated. First, although P&R is often associated, in urban centres, with avoided car trips (and therefore emissions), in achieving the interception of those trips, congestion and resulting environmental externalities may well have increased at and beyond the fringe of urban areas, in green-belt zones and other rural areas. One reason for this paradoxical outcome is the direct presence of surface car parks with associated lighting and access infrastructure, which make P&R sites more attractive and perceived as safe by users. Second, whilst the majority of P&R users are usually found to be motorists who would have previously used the car for the whole length of the trip without P&R, the empirical evidence also points to a significant presence in P&R sites of public transport users who did not previously use cars (Papoulias and Heggie, 1976; Parkhurst, 1995). In other words, by incentivising the use of P&R for the final leg of the trip through cheap, accessible parking, P&R schemes have unexpectedly attracted some people from bus and train services, with the consequence being that they use cars for the main leg of the journey. The behaviour of these users generally represents a relatively large reduction in public transport use and an overall increase in car use. Third, in addition to this *abstraction* of travellers onto P&R from other public transport modes, a level of trip generation and attraction of new trips not previously made to that city can occur (Parkhurst, 2000b). Overall, and contrary to the assumed car traffic-reduction benefits of P&R, there is a lack of evidence for consistent reductions in mean vehicle-km travelled (VKT) by users, while some evidence demonstrates that, in several cases following the introduction of P&R, total traffic actually increased (Parkhurst and Stokes, 1994; Parkhurst, 1995, 2000a; Guillaume-Gentil et al., 2005; Mingardo, 2013).

P&R could possibly encourage a step-change in motorists' travel behaviour towards using public transport for the entire trip – if they form a favourable impression of P&R from experience, and then decide to try out other public transport options as a result. Or it has the potential to raise the profile of public transport more generally. However, the removal of conventional public

transport trips and the encouragement (or even incentivising) of car travel to access P&R outweigh these benefits (Meek et al., 2010). Concerns with P&R have also been raised in relation to issues of social equity. Except perhaps in very specific circumstances, such as airport parking, dedicated P&R sites will rarely be commercially viable in terms of recovering the costs of infrastructure investment and operations. Rather, they generally receive public subsidy justified by the social function of improving accessibility by offering lower-cost parking options (Bos, 2004). Access to P&R is most often predicated on car ownership; however car ownership is often taken as a key measure of social inclusion. Therefore questions of equity may arise where P&R schemes are developed and subsidised at the expense of conventional public transport: in the UK context citizens with cars available may be provided with free parking and subsidised bus fares in order to incentivise P&R use, whilst those without access to cars face market-rate fares on mostly deregulated, privatised bus services (Parkhurst, 2003).

Whilst several of the detailed studies are from England, the unintended consequences of P&R are not exclusive to the UK; similar issues have been observed in the US (e.g. Bowler *et al.*, 1986; Merriman, 1998; Foote, 2000). In mainland Europe a slightly different situation exists due to greater heterogeneity in the types of P&R system in operation, which includes a mix of both bus and rail-based remote P&R systems, peripheral P&R systems, and mixed P&R systems (Mingardo, 2013). The negative implications of trip abstraction and trip generation will be perhaps less severe in the context of remote P&R and local P&R, in which the proportion of the trip length made by car is relatively small. Nonetheless, studies have observed these effects in some European contexts, including in respect of rail-based P&R, and also highlight the abstraction of trips from bicycle to P&R, reducing active travel trips and negatively influencing wider health and wellbeing outcomes. These latter negative effects have not been observed in studies conducted in the UK and US (e.g. Mingardo, 2003, 2013; Guillaume-Gentil et al., 2006; Holwerda and van Dalen, 2006).

Local parking policy is one of the key factors influencing travellers' mode choice for journeys to city centres. Local policy is largely determined by local authorities, within a framework influenced by national government and local interests. Urban parking policy has a number of rationales, not all of which relate to traffic reduction such as facilitating traffic flow by avoiding highway obstruction (IHT, 2005). In this context, parking policy is viewed as an integral tool in preserving or strengthening urban centres' vitality, given the economic competition between commercial centres e.g. city centre high streets, out-of-town commercial centres. Hence, increasing city centre parking capacity, or reducing its price, is also promoted despite the negative implications for traffic. Another factor is the role of parking operations in raising revenue for local authorities from parking charges. Parking revenues can offer a local authority a potentially significant revenue stream which can be allocated to transport or non-transport budgets in line with locally-determined motivations and justifications. However, parking regimes which emphasise ease of car access and peak parking demand provision are also associated with economic inefficiencies characterised with urban sprawl, most notably in the US (Shoup, 2005; Litman, 2012).

Marsden and May (2006) therefore argue for parking policy to be developed as part of an integrated transport and land use planning process with a regional as well as local remit. Moreover, although the importance to commercial vitality of maintaining car access is intuitively a powerful idea, it can be over-stated. The European Commission's Expert Group on the Urban Environment concluded that "*greater urban mobility does not lead to greater economic activity*" (CEC, 1996). Specific mechanisms which can explain this finding are that, where commercial centres have a fundamental economic weakness, parking policy will be insufficient to overcome it, whilst at the other extreme, visitors will not be deterred from reaching the most attractive centres even if car access is hard (Parkhurst, 1993). Nevertheless, motorists' perceptions about

the ease of parking emerge as a significant influence on congestion in medium and large-size towns. Shoup (2005), from a review of studies covering eleven major cities found that they varied very considerably in terms of the share of traffic generated by drivers circulating in streets solely to seek a parking space (8-74%), but on average a space took around 8 minutes to locate. Others found that if commuters can count on a guaranteed parking spot at their destinations, more than 90% will use the car (Kaufmann and Guidez, 1998), despite congestion. Therefore public demand for available and low cost parking can be a powerful political influence on local elected representatives and local authority officers.

In practice, parking policy tends to reflect a compromise between: (i) parking availability being a facility to attract wealth-generating visitors, and (ii) its role as one of the few engineering tools with a strong influence on traffic and congestion. Hence, regulations are put in place to limit who can park, where they can park, for how long, and at what price. These instruments are typically applied according to the perceived economic priority of the associated journey purpose on the one hand, and on the other hand, the emphasis which the regulatory authorities place on equitable treatment for different classes of motorist, independent of economic priority. The findings of the present study contribute to the need for continued research and data on traveller motivation through the unique comparison of drivers' use of P&R and conventional urban parking within a consistent policy context.

3 Case-study context

A case-study method was adopted for this research in order to combine detailed information about travellers collected specifically about parking choices with contextual information about a city and its subregional context. Such intensive research strategies enable detailed explanation of phenomena in the chosen case and can offer hypotheses and tentative, but inevitably provisory, explanations about similar phenomena elsewhere (Swanborn, 2010; Yin, 2009).

The city of Bath has 60,000 inhabitants and is a main service centre for the area governed by the Bath and Northeast Somerset local authority (BaNES), which comprises 170,000 inhabitants. Bath is also part of an economic and political subregion of one million people, dominated by the city of Bristol (located 20km to the west). Bath city is a UNESCO World Heritage Site, and much of the city is a designated conservation area (BaNES, 2009). Bath is a popular destination for tourists attracted by its urban aesthetics, Roman heritage, museums, and literary associations. Bath is also an important employment centre for the area, and its thriving leisure and tourism industry is important for the local and regional economy (WoEP, 2006).

Bath has had an intense debate about balancing the demands for motor vehicle travel and enhancing the environment for several decades. The city's historic design and street layout imposes severe constraints on road traffic capacity, creating a tension between the need to protect the unique built environment and its inhabitants from the detrimental impacts of high volumes of motorised traffic accessing the centre, while at the same time maintaining sufficient accessibility to its main tourist attractions, service points and other economic activities. City centre and residential parking controls and pricing are now widespread, and there has been a long-running policy debate about the merits of further investment in P&R. Bath's P&R scheme was introduced in the 1980s as an initiative to assist in achieving this balance by providing travellers with good access to the city, and at the same time attempting to manage and reduce the number of car trips in the historic city centre (Meek et al., 2010; WoEP, 2011). The Bath P&R scheme follows the 'typical' model of peripheral P&R in the UK, comprising three dedicated P&R sites (Lansdown, Newbridge, and Odd Down) built next to main roads on the southern, western and northern outskirts of the city, variously 2-6km from the urban centre (see Map 1). It has been

an objective in local transport policy to provide a site also to the east of the city, although this is contested by local interests concerned with the environmental impacts and doubting the traffic reduction benefits. User charges for the Bath P&R scheme are levied on use of the bus, whereas parking the vehicle is free of charge. Approximately 2,600 spaces are offered in the three P&R sites compared to a similar capacity in long-stay city car parks of 2,774 spaces (BaNES, 2013; Visit Bath, 2013). CCCPs see high patronage even though parking charges are relatively high for a medium-sized UK city; approximately £10 to park all day (Table 1). On-street parking in and around a 10-15 minute radius of the city centre is closely regulated in terms of maximum permitted stays (mostly of up to two hours) and within the city centre this is also mostly subject to charges. Bath contains a large amount of residential property in and immediately adjacent to the city centre. Residents' parking zones have been implemented which restrict legal parking to residents and hotel visitors who have purchased permits.

Table 1 – P&R and CCCP sites and their approximate costs (2013)

Site	Cost
P&R – Lansdown	£3.20 (return)/£13 (10 journey ticket) – Price per passenger
P&R – Newbridge	£3.20 (return)/£13 (10 journey ticket) – Price per passenger
P&R – Odd Down	£3.20 (return)/£13 (10 journey ticket) – Price per passenger
CCCP – Broad Street	1-4hrs (£1.60-£5.40) – Price per vehicle
CCCP – Cattle Market	1-4hrs (£1.60-£5.40) – Price per vehicle
CCCP – Kingsmead Square	1-4hrs (£1.60-£5.40) – Price per vehicle
CCCP – Podium	1-4hrs (£2.20-£5.50) – Price per vehicle
CCCP – Saw Close	1-4hrs (£1.60-£5.40) – Price per vehicle
CCCP – Manvers Street	2-12hrs (£3.10-£12.50) – Price per vehicle
CCCP – Charlotte Street	4-12hrs (£5.40-£8.50) – Price per vehicle
CCCP - Southgate	2-8+hrs (£3.30-£13.00) – Price per vehicle

4 Methodology

Data relating to current and perceived alternative travel behaviour choices alongside basic personal information about the travel and any companions were collected using on-board and on-street surveys of P&R users and CCCP users in Bath. The dataset permitted a unique comparative analysis of the revealed parking choices and travel behaviours of people accessing the city centre. Both surveys were conducted during the summer months of 2011 following a random sampling strategy.

Face-to-face surveys were conducted with passengers making both inbound and outbound journeys on buses serving all three P&R sites. Surveys were carried out from 09:30 – 18:00 Monday to Saturday (P&R services in Bath did not run on Sundays at the time of the survey). In order to compare car users' travel behaviours and choices, the P&R data presented here represent only respondents that used a car to access the P&R site, whereas those arriving by other modes at the sites were excluded. Having arrived by car was defined as either being the car driver, the car passenger (with car parked at P&R site), or car passenger (with car providing a lift to P&R site but not parked). The on-board survey returned 721 valid responses from P&R users. Similarly, face-to-face surveys were conducted with travellers using CCCPs. Visitors to all of

the major public car parks in Bath city centre were surveyed. Identical to the on-board surveys, these were carried out from 09:30 – 18:00 Monday to Saturday. The on-street survey returned 564 valid responses from CCCP users.

Respondents in both surveys were engaged at random during the surveyed times of day and days of the week. The random sampling methods employed for the P&R survey consisted of sequentially cycling through the rows of seating inside the bus (i.e. first journey – row number one sampled, etc...). In the event a row was empty upon selection, the next nearest passenger would be approached. Random sampling for the car park surveys was achieved by approaching every third person to exit the car park during the survey periods. In the event that a person declined, the pattern would be resumed until a participant was found. Participants were invited to answer a set of questions about their travel on that specific day and more generally. They were also asked to provide the postcode of their trip origins, which were later geocoded. The relevant questions from the survey are included in Table 2.

Table 2 – Survey questions

Park and Ride users	City centre car park users
<i>Journey purpose</i>	
What is the main reason you are going to/have been to central Bath today?	What is the main reason you are in central Bath today?
<i>Number travelling in party</i>	
A) Including you, how many people aged 18 or over are travelling with you (in your group) today on this bus? B) And how many people aged under 18?	A) Including you, how many people aged 18 or over travelled in the car with you today? B) And how many people aged under 18?
<i>Frequency of trips to central Bath</i>	
How frequently do you visit central Bath on average?	How frequently do you visit central Bath on average?
<i>Likely alternate mode</i>	
If Park & Ride hadn't been available today, which of the following would you have most likely done today instead?	You arrived by car in central Bath today, but what would have been your most likely alternative transport option to driving all the way into the city centre today?
<i>Gender</i>	
Question not asked – answer ascertained by interviewer	Question not asked – answer ascertained by interviewer
<i>Age</i>	
Which age band are you in?	Which age band are you in?
<i>Postcode</i>	
What is the postcode of the place you began your journey today?	What is the postcode of the place you began your journey today?

The survey form was interviewer-completed, and not visible to the respondents. Respondents were informed of the purpose of the research, asked to provide consent, and offered an information leaflet. It should be noted that the surveyed times excluded the morning rush-hour which mainly attracts commuters. However, these travellers were sampled later in the day,

during the afternoon hours, on their return journeys from work, when it was expected they would be more willing to respond. Therefore, the sampling frame was robust for comparison between the two parking options but each survey may not be fully representative of the P&R and CCCP user populations, for example in terms of journey purpose proportions. The surveys were coded and entered into a common database.

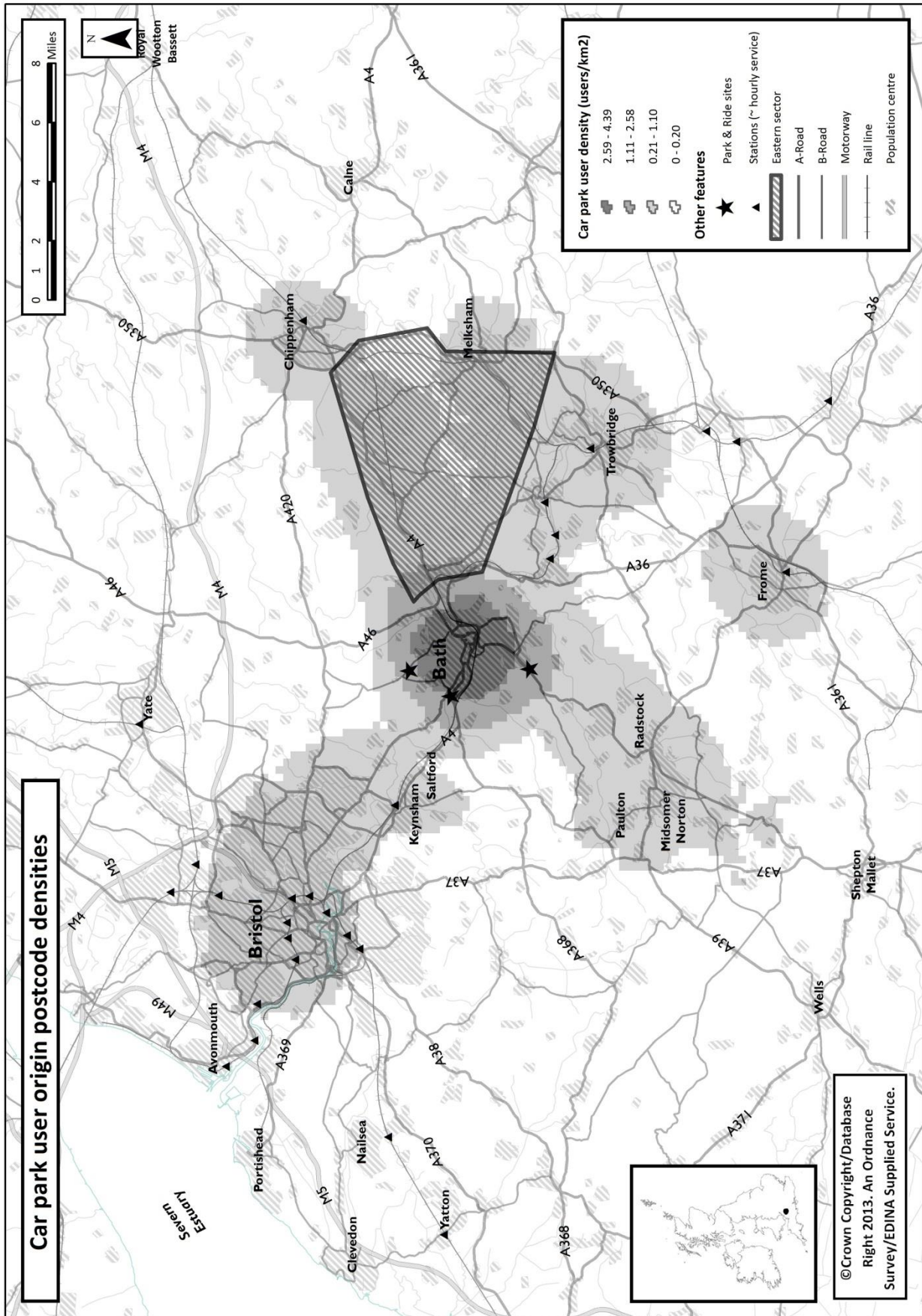
Data analysis included both spatial and non-spatial techniques. Spatial analysis employed point density mapping using the ArcGIS software package to examine the main clusters of trip origins of P&R users and CCCP users and identify spatial factors for statistical analysis. Next, using the SPSS package, cross-tabulations with a chi-square analysis were performed to identify nominal and ordinal factors, including spatial ones which showed a significant difference between the two groups of users – P&R and CCCP. Significant factors were then analysed in a binary logistic regression (BLR) model in order to allow estimation of a choice model between the two types of parking. The BLR model enabled a test of both main effects and interactions. Respondents were also asked what their most likely alternative mode would be (if any), assuming that the one being used on the survey day - either P&R or CCCP - was not available.

5 Results

Map 1 illustrates that P&R users are more densely clustered in areas to the west and south of Bath, with high densities of users travelling from urban areas located on the trunk roads into the city which are served by the three P&R sites (e.g. Keynsham, Midsomer-Norton), and in some cases are also well served by intra-regional public transport. There is some evidence of clusters in areas which are not located directly on trunk roads, but which are still reasonably well connected to the P&R sites (e.g. Trowbridge). The northern P&R site (Lansdown) is not located on a primary route, and it is apparent that users of this site are dispersed at lower densities across a wide area, as opposed to the clustered pattern evident for travellers using primary roads to access the western (Newbridge) and southern (Odd Down) sites.

Map 2 demonstrates the highest densities of CCCP user-origins being in close proximity to Bath, with significant proportions of CCCP users travelling from within the urban boundary of Bath itself, driving rather short distances into the city. This was verified by a spatial analysis which showed that 29% of CCCP users' journeys start within a 3.2km radius of the city centre. This distribution is not surprising considering that the Bath P&R sites are located 2-6 km away from the city centre, meaning that motorists originating from within this radius would need to drive away from the city centre to access these P&R sites, and travellers to the city centre would not normally be expected to do this. In addition, there are no dense clusters around outlying towns and villages as observed for the P&R users, with the pattern of demand generally reflecting the distribution of the subregional population in a settlement hierarchy headed by Bristol.

Considering travellers' socioeconomic and demographic characteristics, Table 3 presents the results of the cross-tabulation and chi-square analysis used to compare the characteristics of user groups. Following the postcode point density analysis, the CCCP user data were split into two subgroups: those who travelled from outside of the 3.2-km radius of the city centre (CP-Out), and the other group that travelled from within that radius (CP-In). This distinction enabled the analysis to take account of P&R not being an 'intuitive' option for trips starting within the city; requiring a car journey oriented away from the city centre. (Nonetheless, 7.2% of the P&R trips did actually originate from within the radius, indicating there was sufficient attraction for some travellers.)



Map 2 - City centre car park user origin postcode densities

Maps 1 and 2 further illustrate an area identified through the analysis of traveller origins and referred to as the 'Eastern Sector'. Virtually zero demand for P&R use is expressed from this area, as there is a lower level of accessibility to all three P&R sites than from other spatial orientations, and relative accessibility is likely to be a key factor in whether P&R is chosen for most motorists. Notably, the absence of P&R use from the Eastern Sector is not, by inspection, obviously mirrored by a higher density of demand for CCCP use, this reflecting the principally rural nature of the sector, its relatively sparse population, and modest overall contribution for demand for travel to Bath: just over a tenth of CP-A users had origins in this area.

Table 3 – Descriptives of P&R users and CCCP users

Factor	N				Categories	%			χ ²	
	P&R	CP-Out ^a	CP-In ^b	Total		P&R	CP-Out ^a	CP-In ^b	stat	p
Age	721	399	162	1282	18-34	16.1	24.6	22.8	166.43	<0.001
					35-59	36.9	62.9	62.3		
					60+	47.0	12.5	14.8		
Gender	721	398	162	1281	Men	35.4	49.2	40.7	20.53	<0.001
					Women	64.6	50.8	59.3		
Journey Purpose	721	401	163	1285	Work/Ed. ^c	20.4	21.4	16.0	9.47	0.151
					Shop/P.B. ^d	58.7	59.9	68.7		
					Leisure	16.2	12.5	11.0		
					Other	4.7	6.2	4.3		
Income /week (£)	622	341	163	1126	<350	5.1	4.4	8.0	53.62	<0.001
					351-410	37.5	34.6	27.6		
					411-460	43.7	34.6	28.8		
					>461	13.7	26.4	35.6		
Trip Frequency	720	401	163	1285	>3 trips/week	27.3	19.2	54.0	81.53	<0.001
					>1 trip/month	49.5	56.6	41.7		
					Rarely/first	23.0	24.2	4.3		
Party Size (adults and children)	717	396	162	1275	1	61.9	49.2	55.6	21.69	<0.001
					2	27.2	37.1	35.2		
					3	7.1	8.3	8.0		
					4+	3.8	5.3	1.2		
Eastern Sector	721	401	163	1285	Yes	0.1	11.0	0.6	92.38	<0.001
					No	99.9	89.0	99.4		

^a Car park users travelling from outside 2 mile radius of central Bath

^b Car park users travelling from within 2 mile radius of central Bath

^c Education

^d Personal Business

Chi-square analysis revealed significant differences between the shares of the three user groups in relation to age, gender, journey purpose, income and party size travelling together. In respect of the age distributions of P&R and CCCP users, the highest proportion of P&R users were in the 60+ age group (47%), compared to the highest proportions of CCCP users being those in the 35-59 age range. A likely explanation for this finding is the UK concessionary bus pass policy, whereby most bus services after the morning peak, usually including P&R buses, are free to UK residents of pensionable age (DfT, 2010). Concessionary pass holders are therefore able to use the Bath P&R scheme completely free of charge (i.e. both vehicle parking and bus travel), suggesting that this tends to increase the attractiveness of P&R for this population group (and also represents one of the possible explanations for why some Bath city centre residents might in fact drive out of the city to a P&R site in order to visit the city centre). In relation to gender, a significantly higher proportion of women were found to use P&R compared to men. This result

mirrors the national gender difference found for local bus services (DfT, 2012). In contrast, CP-Out has an approximately even gender split, whereas CP-In included significantly higher proportions of women driving relatively short distances into the city centre than men ($p < 0.05$). A possible explanation for the gender disparity is the difference in journey purpose. Significantly higher proportions of men had travelled into the city centre for employment or education (+8.7%) and leisure or socialising (+6.9%), whilst higher proportions of women (+21%) had travelled for the purposes of shopping or personal business ($p < 0.05$). Hence, it is possible that the gender difference is accounted for by the use of cars to carry shopping from the city centre, whilst an unencumbered commuting journey might be more readily made on foot, bicycle, or public transport. Shopping trips are in general of shorter duration than work and study trips, so the parking fees incurred would be lower.

Regarding journey purpose, no further significant differences between the groups were found: across both P&R and CCCP users, the highest proportions of travellers were accessing the city centre for shopping and personal business, with lower proportions travelling for employment and education, and fewer still for the purposes of leisure or socialising. It should be noted that the P&R service in Bath did not run late into the evening (finishing at 20:30), which may have had a negative impact on people using P&R for the purposes of leisure or socialising. Income was also found to be of significance. The levels of income were inferred by analysing the participants' origin postcode data in comparison to average household incomes by area, sourced at the Medium Super Output Area (MSOA) level from national UK census data. It is acknowledged that for a small share of trips, the assumption that the point of origin was in the home neighbourhood will not hold. Bath and its surrounding areas are relatively affluent, and have a higher-than-average household income compared to the UK median average of £1,556/month (ONS, 2012). There is a significant difference between P&R and CCCP users in respects of income, with higher proportions of P&R users' trips originating in areas in the middle income categories (£1,521-£1,993/month), and higher proportions of car park users trips originating in areas in the highest income category (>£1,998/month). This gap is particularly large in the cases of CCCP users who travelled from within the 3.2km radius: more than 35% of these participants' trips originated in a high income area. Participants' trip frequencies were also significantly different between the three groups, with the P&R and CP-Out groups having very similar frequency patterns. Conversely, as might be expected given proximity, CP-In travel more frequently; more than half travelling three times a week or more. The availability of discounted season ticket parking suggested this might be related to a high number of travellers for employment from this zone. However, on further inspection there seems to be little difference in the rate for trips to work on either side of the radius (10.4% from within/9.5% from without), whereas a significantly higher rate for shopping trips from close by was identified (58.9% within/48.4% without: $p < 0.01$). Finally, in terms of party size, P&R users were significantly more likely to be travelling alone relative to CCCP users from both distance ranges, although the majority in each of the three groups was travelling alone. It is likely that user charges (per group for bus-travel; per adult on the P&R bus) incentivises groups to use CCCPs rather than P&R. However, although more people in the larger groups did list cost as a reason for not using P&R than in the smaller groups, there was a low number of respondents in the larger groups and the comparison was not significant. Moreover, some groups of four or more travellers did in fact use P&R, so this is an issue which would benefit from further research.

A binary logistic regression (BLR) model was estimated to explore which of the significant factors found previously would contribute to explaining the choice of parking type: P&R or CCCP. Note, this is not a classic stated-preference-based mode-choice model where respondents are asked to hypothetically rank preference based on a set of defined attributes of the possible alternatives; rather the choice is based on revealed preference as found in the field, i.e., the non-chosen

alternative is always normalised as having a preference ranking (or utility) equal to 0. All of the significant variables presented in Table 3 were tested in the model: different combinations of factors were tested, including main effects and two-way interactions controlling for the effect of distance (a main suspected determinant). However, the main effects model provided the best goodness of fit and was more parsimonious in terms of the number of estimated parameters. The model results are presented in Table 4.

Table 4 –Binary logistic regression model for choice of P&R vs. car park*

Factor	β	S.E.	t-stat	p
Gender (women)	0.682	0.149	21.105	<0.001
Age (60+)	2.005	0.176	129.411	<0.001
Income (highest)	-0.581	0.186	9.744	0.002
Party (travelling alone)	0.527	0.145	13.152	<0.001
Eastern Sector (yes)	-4.234	1.042	16.523	<0.001
Distance (<3.2km)	-1.991	0.201	98.260	<0.001
Frequency (>1 trip per month)	0.390	0.145	7.199	0.007

Goodness of fit measures: Nagelkerke R-Square: **0.391**; McFadden pseudo R-Square: **0.252**
Initial log-likelihood: **-787.026**; Final log-likelihood: **-592.070**

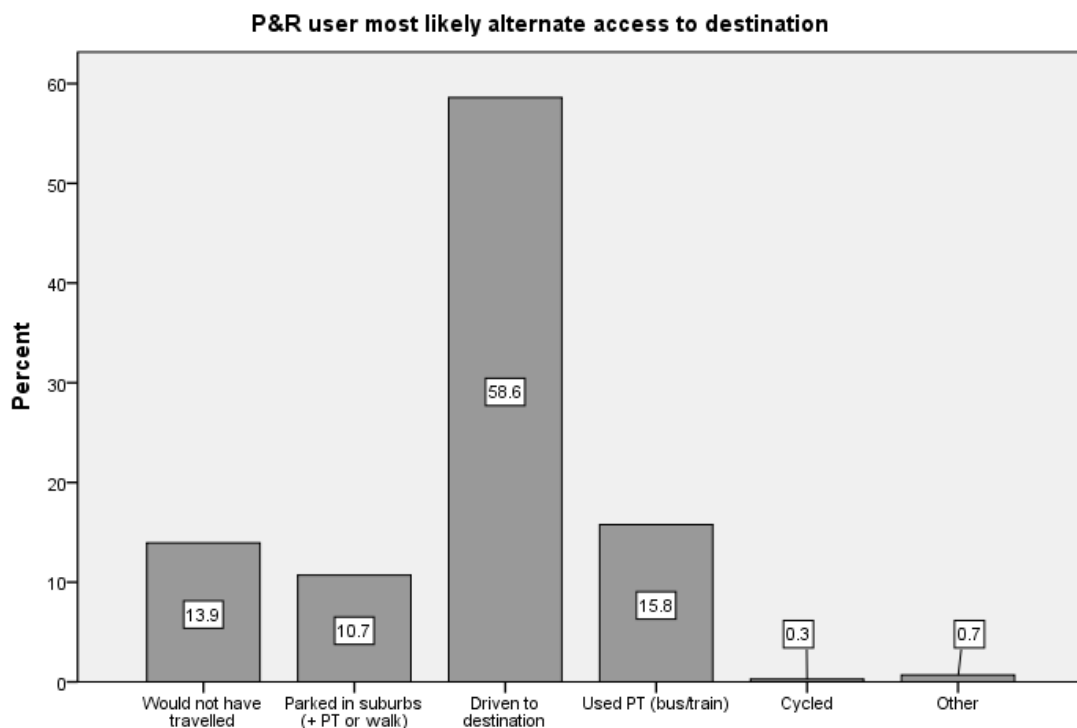
The model displays a good goodness of fit, and it is evident that there are seven factors which contribute to explaining parking choice. The model shows that women are more likely to use P&R compared to men; travellers aged 60+ are more likely to use P&R compared to those aged 18-59 (note: disaggregation to a larger number of age groups did not show significant effects); people travelling alone are more likely to use P&R compared to those travelling with others. Finally, those travelling in the middle frequency category are more likely to use P&R compared to those travelling in the higher and lower frequency categories. In terms of CCCP use, those travelling from areas in the highest income category (>£1,998/month) are more likely to use CCCPs relative to those travelling from areas in the medium-to-lower income categories. Spatial factors were also found to have an influence on choice behaviour with people travelling from within the Eastern Sector more likely to use CCCP, as are people travelling from within the 3.2km radius of the city centre. The BLR model largely confirmed the results of the descriptive chi-square analysis, although the medium frequency of trip-making to Bath emerged as an additional explanatory factor for P&R use. This is explained by the model considering origins within and beyond the P&R sites as a single variable and hence reflects the much higher frequency of visiting the city centre through CCCPs by those living within Bath itself.

Unsurprisingly, the main improvement in log likelihood was related to whether an attractive opportunity to use P&R exists; generally not the case for trip origins in the Eastern Sector or within the 3.2km radius. Otherwise, the user group of senior citizens (mostly eligible for a concessionary bus pass) was associated with greater P&R use, as were to a lesser extent being female or travelling alone. As noted earlier, relative user costs offer important though partial explanations for the age and group-size effects. Past research has also identified the importance of P&R enabling the user to avoid the stress of city centre driving and locating city centre parking (Parkhurst and Stokes, 1994). In addition, in respect of gender, the data show that a significantly higher proportion of women are using P&R for accessing employment in comparison to men ($p < 0.01$): 81.1% of female respondents travelling for employment purposes used P&R and 18.9% used CCCPs whereas amongst male participants travelling for the same purpose 51.9% used P&R and 48.1% used CCCPs. The effect possibly reflects gender-differences in employment such as the higher likelihood of women being in part-time work and, for multiple reasons, having lower earnings. It can be suggested that women working part-time may well be

more resistant to spending a greater share of earnings on transport, regardless of overall household income.

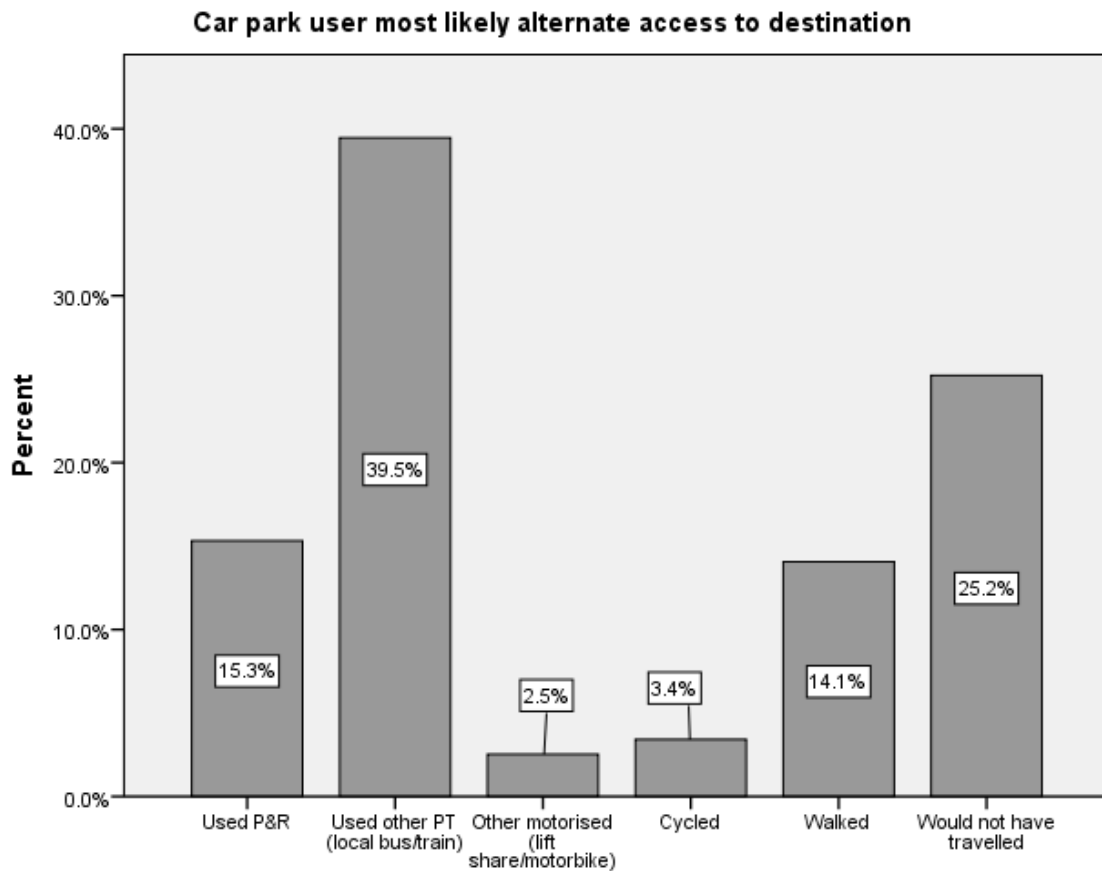
Foregone behaviours are reported in Figures 1 and 2. A note of caution is required in interpreting these results given their hypothetical nature. As demonstrated in Figure 1, 60% of P&R users reported they would have chosen to drive to a CCCP; the share of P&R users that represents intercepted car traffic on the final leg of the trip. Another 14% reported that they would not have travelled. Such responses are hard to interpret without further data regarding the attributes of these foregone alternatives. Possibly they suggest a tendency for trip reduction to the city-centre to be substituted to some degree by travelling to other destinations. Interestingly, more than a quarter of the P&R users would have either used public transport from afar (most likely from nearer their points of origin than the P&R site) or parked in the Bath suburbs and continued the journey on foot or by public transport. This reflects the P&R unintended consequence, whereby a substantial number of individuals (a large share of which are also senior citizens) may well have behaved more sustainably without the P&R alternative being available.

Figure 1



As demonstrated in Figure 2, similar issues arise with interpreting the 25% of CCCP users who reported that the trip would not have been made. Otherwise, almost 40% of CCCP users stated they would have taken public transport whilst 18% would have walked or cycled to reach the city centre and another 15% would have used the P&R option. Here again it is evident that more sustainable behaviour may well have been achieved if they second-choice option had been selected.

Figure 2



6 Discussion and Conclusions

The comparative analysis of Bath users’ behaviour, which applied various spatial, socioeconomic and demographic predictors, makes an important contribution to the ongoing debate about the sustainability contribution of P&R schemes. The empirical results indicate that older age, gender (women), party-size (travelling alone) and income are strongly associated with the decision to use P&R, whereas travel distance and availability of P&R site – as in Bath’s ‘Eastern Sector’ – also influence the decision to use CCCPs. Trip frequency and purpose do not seem to have much weight in this decision.

These findings from Bath contribute to a growing body of knowledge concerning the P&R controversy and the importance of having a sustainable and strategic subregional parking policy in place. Previous studies asserted that, by capturing the final leg of the car trip, P&R becomes a substitute for more sustainable travel behaviours for the longer legs of the same trip. The spatial analysis which showed P&R trips originating mostly from within the Bristol-Bath subregion, and respondents stated responses on foregone alternatives, support this perspective. Following the findings of Mingardo (2013) on P&R substitution of more active travel, at least in the level of stated behavioural intentions, in Bath similar effects can be found regarding the potential for walking/cycling to replace short car trips. Bath is a compact city, which makes walking a credible alternative, thus the alternative to ‘park and walk’ is not unlikely and has indeed already reported from much larger cities e.g. Belgrade (Simićević et al., 2013). However, Bath has a hilly topography and its residential population is relatively affluent compared to the national

average. This combination is also likely to be associated with the high shares of car use for travel to the city centre by respondent residents, despite high parking charges. It is likely that these travellers are more influenced by parking space availability and access restrictions rather than parking price.

The Bath findings exemplify well the transport policy dilemmas faced by local authorities seeking to manage mobility in urban areas according to sustainable transport objectives. The prospect of a P&R site to the east could be deduced to be a logical next step in 'completing the ring' around the city. Undoubtedly, this site would provide an attractive journey option to motorists originating outside Bath from the east, reducing their tendency to park in the city centre. However, clearly this site would also stimulate some counter-sustainable behaviours including mode switches from subregional public transport and attracting more car trips from Bath's periphery itself. Given the low relative overall demand from the east, questions are also raised about viability in patronage terms given the investment costs of a new site, and on-going revenue support costs of the bus service. Moreover, an edge of city P&R service will reinforce the car dependence of the Eastern Sector, rather than contributing to a genuinely multimodal rural-to-urban transport system.

The findings therefore create a challenge for future policy in Bath: the analyses demonstrate that to close down existing P&R sites could well lead to an increase of motorists driving into the city and parking in the city centre. However as noted, increasing P&R provision may well lead to adverse effects on levels of public transport use and active travel. Therefore a pragmatic solution which begins to move policy in a more sustainable direction is arguably to maintain current edge-of-city P&R provision but not increase it, while focusing on improving strategic planning of public transport and parking strategies. For example, one alternative policy package might be to provide a more localised P&R capacity sited at a new railway station at Corsham (at the time of writing the subject of a feasibility study) and at different locations on the existing bus services to Chippenham and Melksham, with the additional patronage potentially supporting an increase in bus service frequency (over the current 30 min and 60 min intervals) based on the Link and Ride concept (Parkhurst 2000a). Hence, the transfer of entire car trips to public transport, as well as the significant shortening of car trips, would likely be supported. Chippenham and Melksham could also benefit from this potential service. Alternatively a hybrid of the 'hub and spoke' and 'integrated' concepts proposed by Meek et al. (2011) could envisage a single site located intermediately, 10km from Bath, in the north-centre edge of the Eastern Sector near the village of Box where the bus routes coincide, and already provide three services per hour to Bath. Whilst this latter approach would not offer the same car-trip shortening benefits, it would not require additional bus-km to be operated, would reduce the abstraction effect and not attract P&R trips with origins in Bath itself.

Although assumed to be a UK-specific issue, the results also appear to raise a concern related to the linkage between equity and sustainability in bus P&R schemes. Equity and justice considerations have been growing in importance in the transportation research literature in general (e.g. Martens, 2012) and, as noted in Section 2, have been considered in respect of P&R in the past. In recent years, equity issues in the UK have sharpened, following the policy that enables senior citizens who are residents (in the Bath case) of England, and of pensionable age, to be subsidised to travel by local bus, free of charge, supported from national taxation. The public policy rationale behind the concessionary fares policy was to motivate public transport travel, allowing greater mobility and improved accessibility to this age group, as well as gaining sustainability benefits for the rest of society. However, concessionary pass users who drive to P&R sites also benefit from the parking subsidy provided to all P&R users. As the concessionary pass is not means tested, it is in any case criticised for generating consumer surplus amongst wealthier senior citizens, many of whom own cars. In the case of P&R, the 'double subsidy' will

for some senior citizens be creating a 'best of both worlds' scenario of free parking and free bus travel. Where access to local public transport services is foregone in favour of P&R for the last journey leg, the concessionary fares subsidy will be contributing to reducing rather than increasing sustainability, at the expense of the tax-payer. A measure to reduce this counter-policy incentive is to charge for the parking of the vehicle as well as for bus travel, as has been applied in the UK at P&R sites in Oxford and Cambridge. This revised policy would also have the wider benefits of reducing the use of P&R car parks by travellers not using the bus to access the city centre, encourage carpooling to the sites, and reducing P&R operating subsidies met from local taxation. One disbenefit of charging for parking which requires further evaluation would be the risks – depending on the local situation – of P&R users choosing to park in surrounding roads rather than using the official car park, although this could potentially be contained through local area parking restrictions. Another potential disbenefit would be the deterrent effect on use of making a double-charge transaction. However, with modern ICT-enabled payment systems, such as smartcards, now being widely available such transactions could be made near-seamless.

To conclude, Bath's case-study exemplifies the justification and need for an integrated mobility approach as also recommended by Marsden and May (2006). Given the specificities of the UK context in relation to both operational and institutional constraints at local and national government levels there is a need for further exploration and research into the behavioural impacts of combined parking and public transport strategies in a wider range of public policy and national contexts.

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