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TRL Limited  
Parking Measures and Policies  
Research Review

Client: The Department for  
Transport

May 2010

# Transport Research Laboratory



## PROJECT REPORT

### Parking Measures and Policies Research Review

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**Parking Measures and Policies Research Review**  
**Client:** Department for Transport  
Geoff Dawe

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## Executive Summary

### Background

This project investigated the evidence about the impact of different types of parking measures and policies on road traffic, congestion and transport safety, car ownership, on the level of carbon emissions from transport, on the activity of businesses, and on townscapes. The focus was mainly though not wholly, on urban areas. It has involved a Systematic Review of evidence from original and relevant studies.

The project aimed to support the Department for Transport's (DfT) analytical and modelling capability in terms of improving its understanding of how economic activity is affected by transport investment and interventions such as parking.

For the purposes of this research, the policies and measures considered included pricing (levels, structure and relationship with characteristics of vehicle or user), changes in the supply and location of on-street and off street parking, Park and Ride (P&R), Workplace Parking Levy (WPL), controls on parking provision in new developments, and parking standards in new residential developments. In addition to the intended consequences of parking measures, the review also considered what the literature has to say about unintended or perverse consequences.

In undertaking this research we have considered the policy context set by DaSTS<sup>1</sup> which has five goals for our transport system:

- to support national economic competitiveness and growth, by delivering reliable and efficient transport networks;
- to reduce transport's emissions of carbon dioxide and other greenhouse gases, with the desired outcome of tackling climate change;
- to contribute to better safety, security and health and longer life expectancy by reducing the risk of death, injury or illness arising from transport, and by promoting travel modes that are beneficial to health;
- to promote greater equality of opportunity for all citizens, with the desired outcome of achieving a fairer society; and
- to improve quality of life for transport users and non-transport users, and to promote a healthy natural environment.

Parking policy could play an important role, in particular in supporting economic growth while reducing greenhouse gas emissions.

### Methodology

A six-stage process was undertaken to identify research papers of possible use, extract useful information, consider their findings and their application to the DfT's concerns:

1. Identification of possible papers from journals, reference books etc by virtue of their title or abstract that suggested that the paper might be of relevance;
2. Review of the paper to investigate whether the research reported was relevant to this study;
3. Identification of other research papers in the references for further analysis;
4. Entering the appropriate details in the Access database;
5. Extraction of other relevant information from the document for use in the final report; and
6. Consideration of the utility of the findings for the DfT, especially the goals set out in DaSTS.

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<sup>1</sup> Delivering a Sustainable Transport System, Department for Transport, 2008

The term “parking” can be used to describe two factors:

- The **infrastructure** provided for the storage of vehicles whether on or off-street; and
- Parking as an **activity** forming part of the overall process of car travel.

In this study, TRL has reviewed research that covers both aspects.

TRL identified and reviewed over 175 papers, documents and books of possible relevance to the study and entered their details into the database. Other important information, focussing particularly upon the research results, has been collated from the papers.

The papers cited in this report are those in which we have some confidence in the research methodology undertaken although some are included because they report innovations or interesting results that may be of use.

Five research studies currently being undertaken were identified as being of potential interest to the DfT.

A series of research questions were formulated for each aspect and a conclusion reached. Possible research “quick wins” are also identified.

## Parking types

Parking research in the literature may be categorised generally as focussing on origins and destinations.

Research at origins considers a range of issues including uncontrolled and controlled parking, parking management methods, such as e.g. Controlled Parking Zones (CPZs), Residential Parking Zones (RPZs). Research also considers parking availability and standards at existing and new private residential developments and car-free settlements etc.

The types of parking to be found at origins varies:

- Private off-street parking;
- Public off-street parking (short stay, long-stay, contract);
- Controlled (paid) on-street parking; and
- Uncontrolled (free) on-street parking.

Destinations may be categorised in a variety of ways; the following approach has been adopted for this research:

- General town centres (including P&R and controlled (paid) on-street parking);
- Railway stations;
- Shopping centres;
- Workplaces - Private Non-Residential (PNR) parking;
- Stadia; and
- Airports.

## The Impacts of Parking

The impacts of parking with regard to various planning objectives, include:

- *parking supply* (how much parking is provided in an area);
- *parking prices* (whether users are charged directly for parking, and the price structure used);
- *travel patterns* (the amount of vehicle traffic generated and use of alternative modes;) and

- *equity impacts* (how costs are distributed).

The main area of interest for the DfT is the impact of parking policy upon the following factors:

- Congestion
- Carbon emissions and pollutants
- Sustainable transport
- Business activity and town centre viability
- Urban design, landscape and townscape

## Overview of Results

Many research papers have been published that relate to parking, albeit often indirectly or as part of a study that is investigating other issues. In many, there is little detailed consideration of the issues in which the DfT is particularly interested. Nevertheless potential topics for future research are generated from such papers. Furthermore the papers reviewed have enabled TRL to build up a broad evidence base of useful information.

Much guidance and advice on parking operations is provided to car park operators, developers and local authorities. These reports often cover a range of operational issues including legislation, design, and undertaking surveys. Others set out the main policy considerations that should guide local authority decisions including designers' and local authorities' approach to residential street design to help change it for the better. TRL has reviewed some of these documents primarily in order to identify other publications that provide research results of interest to our inquiry.

Studies are almost exclusively concerned with city and town centres, with little consideration given to rural areas. However many studies are concerned with how access to town centres is affected by parking policies which clearly impacts upon rural communities.

Several papers address parking matters at the national scale, for example policy measures. However some studies cover relatively small geographic areas, sometimes only being concerned with the situation in a few streets; others are concerned with a single town. As a result, the replicability of their results and interpretation elsewhere may be limited.

Some papers have a particular focus such as airport parking, or match-day parking restrictions around stadia. Perhaps surprisingly, there appear to be few papers covering such specialist parking topics.

Several papers are theoretical studies, for example focussing on stated preference results rather than behavioural change that has occurred as a result of the implementation of new parking arrangements. Reviewed studies include those that relate to the public acceptability of controversial policies such as the introduction of workplace parking levies.

Many of the more relevant papers reviewed were published some time ago – notably during the 1990s. As a result, the results and conclusions may not necessarily be relevant to current circumstances. Nevertheless with the continuing rise in car ownership, it seems likely that the impact of parking on congestion and related consequences may be much greater.

Research may have been hindered by the lack of statistics on the availability of parking, especially that related to Private Non-Residential (PNR) parking – over which local authorities have limited controls. This should form the starting point for understanding the relationship between supply and demand and perhaps more research is needed in this area.

Two types of information source are commonly applied in research:

- Cross sectional – comparing the travel responses of different individuals or groups at a single point in time to make inferences about behaviour; and
- Time-series – using direct observations of such behaviour over a period of time.

Most studies have focussed on cross-sectional studies and the picture of behavioural change over time with respect to parking policy is unclear.

## Discussion

Relatively few research papers directly address all the issues in which DfT are interested. Particular gaps arise in evaluation studies, linking parking to congestion, CO<sub>2</sub> emissions and sustainable transport. The impact of parking provision upon the urban environment and streetscape has barely been considered in the papers and reports reviewed. While some studies investigate the impact of parking controls on traffic, this is usually only indirectly concerned with congestion and carbon emissions; traffic levels can be viewed as a surrogate for these variables. As a basis for the policies outlined in DaSTS, the findings as a whole do not provide clear and unequivocal evidence demonstrating the impacts of different parking policies. Nevertheless several papers report very interesting results or interpretations that contribute to the policy debate and help to determine research priorities. This report has helped to build the evidence base for further investigations and policy development.

The level of parking charges set often appears to be relatively arbitrary - parking charges do not necessarily reflect the cost of provision, especially of multi-storey car parks; nor do parking charges reflect the market price and what users would be prepared to pay. Parking is expensive to provide in new developments, but the basis for these costs is not commonly researched.

Some papers report parking costs, sometimes in locational studies, but these may not now be appropriate due to inflation and the time since the study was undertaken. One issue is that whereas charging for parking is traditionally a step-function, with prices increasing incrementally at infrequent intervals, parking demand is a continuous function, having experienced steady growth over recent years. As a result, parking charges tend to lag behind increases in demand so pressure is continuously placed upon the highway network. In this way, parking pricing policies, applied in isolation from other interventions, may not be an effective management measure.

Many studies are concerned with the application of market measures to manage parking, especially in urban centres. Evidence of price elasticities is available but these will be subject to a variety of influences, not only absolute and relative prices, but including availability of alternative parking; public transport provision; real incomes; charging boundaries; trip purposes etc. These will vary between locations so the elasticities for one location may not be replicated elsewhere. Travel behaviour depends on a wide range of psychological, sociological as well as economic issues which also need to be understood - in particular driver behaviour when faced with limited parking.

Few robust evaluation studies have been identified in our research so the impacts of different parking policies upon the key indicators of interest to the DfT have been difficult to discern. This is a general failing – when new parking policies are implemented, they should be independently evaluated and the lessons learnt, particularly their contribution to reducing carbon emissions and congestion. Often short term effects are considered but the longer term effects of parking policy have not received as much attention which are also intertwined with issues relating to driver behaviour and the social acceptability of policy measures.

While interesting in themselves, papers that cover overseas experience may not be directly replicable in the UK. Thus their results should be treated with caution. However these papers often report the most recent research and, despite covering societies with different approaches to the subject, provide a useful insight into the issues.



The methodologies applied in the studies vary. Many studies use surveys. The use of scenarios is also a common feature, particularly with regard to road pricing policy in which parking pricing is often a subset. Others use various models but no standard modelling approach has emerged. Delphi techniques have also been applied.

In terms of survey work, the most common technique used has been Stated Preference surveys, directly asking people about their preferences regarding, for example, parking charge increases. However some have been conducted on relatively small samples. Doubts must exist about the actual behaviour of respondents in real world situations when such issues are considered within the context set by various transport, and non-transport, factors. Parking charges may represent only a relatively small element of a journey's cost and, since much parking is available for free, drivers' responses may be more complex than studies suggest. Furthermore such studies tend to be at a single point in time without considering how behaviour changes. Good Stated Preference surveys can, however, provide a useful indication of the type of response to be expected and an indication of the strengths and weaknesses of different policies for managing parking.

Another problem appears to be the lack of reliable parking information. The stock of PNR parking, one of the key influences on driver behaviour, is generally unknown with surveys only covering part of the provision. This is an issue that needs to be addressed. Likewise the level of on-street and residential off-street parking is also uncertain. These data gaps, which would be very difficult, and costly, to rectify across the whole of the UK, nevertheless impede analysis and hence policy making.

While TRL operates an annual Parking Benchmarking Initiative that collects and tabulates data relating to member local authority's parking operations, it is not applied as a standard for data collection by all local authorities. As a result comparative studies may be difficult. There may also be a need to update the London Parking supply database.

Parking management is defined as the strategic application, and use, of existing and planned parking spaces, both on-street and off-street, in a given area. Parking management is a system management tool which addresses how vehicles access, use (length of time) and egress from parking spaces. These tools include the:

- Designation of long term and short term parking.
- Charging strategies.
- Payment technologies.
- Application of Intelligent Transportation Systems (ITS) technologies in facilities that optimise use within a limited area.
- Implementation of parking demand management strategies to encourage multiple use of parking facilities.

Implementation of parking management strategies includes parking demand, supply, pricing, safety issues and location issues. It needs to consider economic and financial feasibility issues, site characteristics, locational features and compatibility with surrounding uses as well as market and regional issues.

As long as parking policy is viewed independent of transportation policy and as long as on-street and off-street parking are treated independently this dysfunction will continue. Frequently, this manifests in excess car trips, shortages of on-street parking, an excess of empty off-street parking spaces and degradation of public transport services and of the pedestrian environment. Failure to develop coherent policy is a missed opportunity for achieving transportation objectives. Providing a regular parking supply and mispricing appear to be the norm across the world.

### **A Paradigm shift**

In the UK, and now increasingly in North America, parking planning has undergone a paradigm shift, a fundamental change in how a problem is perceived and solutions evaluated. The old paradigm assumed that parking should be abundant and free at most destinations. The aim was to maximise supply and minimise price.

The old paradigm assumed that parking spaces should almost never fill, that parking facility costs should be incorporated into the costs of buildings or be subsidised by local government, and that every destination should satisfy its own parking needs.

It is evident that conventional parking practice is still widely used within suburban areas propagating low density development and urban sprawl.

The new paradigm strives to use parking facilities efficiently. It considers full car parks to be acceptable and that any spillover problems, such as congestion or carbon emissions, should be addressed. It emphasises the sharing of parking facilities between different destinations. It favours charging parking costs directly to users, and providing financial rewards to people who reduce their parking demand. The new paradigm strives to provide optimal parking supply and price accordingly. It considers too much supply as harmful as too little, and prices that are too low as harmful as those that are too high.

The new paradigm recognizes that transport and land-use conditions evolve so parking planning practices need frequent adjustment. It allows new approaches to be tried until their effectiveness (or lack thereof) is proven.

The old paradigm results in predict and provide planning, in which past trends are extrapolated to predict future demand, which planners then try to satisfy. This often creates a self-fulfilling prophecy, since abundant parking supply tends to increase vehicle use and urban sprawl, causing parking demand and parking supply to increase further.

Two basic roles therefore exist for parking policy:

- To determine the way in which parking management is used to meet specific parking system objectives (e.g. balancing supply and demand, revenues to cover costs etc); and,
- To determine the way in which parking management is used to meet other policy area objectives (e.g. traffic management goals, accessibility for business and shoppers etc).

Increasingly parking policy is considered to be a subset of transport policy to achieve transport-related objectives. However, parking policy can also be used to promote objectives in other areas (e.g. economic goals by providing sufficient car parking for new developments), and consequently there are often conflicting perspectives on parking policy.

The main conflict facing policy makers has been the conflict between using parking as a means of enhancing car accessibility, or as a means of selectively controlling car accessibility (and thereby car use).

### **Research Gaps**

There appears to be several gaps in the research: much research was undertaken some time ago and may not be relevant to the current situation; much research is narrow in its focus; travel and parking behaviour has changed since the research was undertaken;

new developments will have influenced local travel behaviour; changes in controlled on-street parking will also have affected behaviour; while data may now be inaccurate. As a result, the robustness or replicability of the results of much research should be questioned.

Nevertheless we are able to identify some information gaps in which the DfT could usefully commission new research. The table below highlights both the research conclusions with recommended research.

**Table: Summary of research conclusions and research requirements**

Research conclusion	Recommended research
Research on parking standards is limited – and surveys which ask people about the flexibility of their current behaviour will potentially produce very different results to those which look at longer term trends, or revealed behaviour based on where people are living.	Undertake some research with local authorities to consider before and after effects of larger scale new developments to determine whether parking standards implemented and alternative mobility measures have influenced travel patterns
Travel plans could be used to help mainstream the car-free concept within the UK making it more attractive to both developers and potential residents with benefits in terms of reduced parking needs. Currently, in car free developments, it seems that improvements in other modes of transport and the provision of green space have not always reached the levels which are seen as necessary to make such developments successful.	Research might investigate the changes to other modes of transport that have accompanied the development of car-free settlements.
Little research exists on the effectiveness of types of demand management measures in residential areas, particularly with regard to longer terms impacts. Car Clubs potentially offer an exciting new opportunity to reduce car ownership in densely populated areas.	More assessment of the impacts of CPZs and RPZs in relation to the prices that people are willing to pay, and the way that such policy initiatives impinge on car ownership would be beneficial.
The availability of parking at destinations appears to be an important factor affecting car use and longer-term decisions about land use. There is some evidence suggesting that high levels of provision can lead to an inappropriate use of valuable land and contribute to car dependency.	
Much research has demonstrated the importance of parking costs to travel choices although the extent of the impact may vary. A combination of parking charges and reducing or restricting parking availability is likely to be most effective in encouraging behavioural change.	
Research on pricing mechanisms asserts that the parking fees do not reflect the full externalities of car usage. Elasticity ranges vary greatly – time, location etc - and therefore must be interpreted within the context they are reported. However they do provide an insight into the social and political acceptability of a range of parking policy measures. Information on long-run elasticities is lacking as few time-series analyses have been undertaken; this is important since parking charges probably lag behind rises in income. Further research is needed into the cross-price elasticities of parking demand with respect to public transport improvements.	<p>An investigation of the responsiveness of parking demand using time series analysis could be undertaken. Further research should be undertaken into the responsiveness of parking demand to public transport fares and service levels as well as incomes. An econometric study could investigate the impact of parking behaviour in response to income and parking charge changes over time.</p> <p>Given the range of figures cited by the various studies quoted, a meta-analysis of the available research that have calculated price elasticities could be undertaken to generate a better estimate of the values in the UK.</p>
Controlled parking zones in city centres are a potentially important policy measure, although problems of enforcement arise, together with the potentially undermining factor of PNR parking. Data on PNR parking is non-existent or, at best, incomplete.	An analysis of several towns or cities with CPZs could be carried out, looking at issues such as enforcement, and the role and levels of PNR parking, within the context of an understanding of how the places' strategies have evolved over time.
Much research has been undertaken into the impact of P&R. But while P&R is a popular policy the research evidence identifying its benefits appears unclear: while it may extract traffic from town centres it may also	A practical trial of a link-and-ride scheme, together with an evaluation of its impacts, could form a useful addition to the knowledge base.

encourage longer car journeys to access the facility. Much will depend on the circumstances in which it is introduced.	
Interchange penalties are an important deterrent to rail travel and combined with the waiting time may discourage public transport use. Parking is therefore potentially needed at railway stations as well as at appropriate drop off areas for "kiss and ride" commuters. However, parking provision may also encourage undesirable behaviour, such as extracting demand from other stations, creating congestion around stations, undermining pedestrian and cycle access and using land otherwise available for sustainable development. Hence, this is a complex issue, worthy of further research.	It might be useful to develop a typology of different types of stations, and different types of locations, in order to identify the levels of parking which could be appropriate in different situations.
Research suggests that it is not just parking charges that influence shoppers' behaviour.	
Research demonstrates that the provision of, usually free, PNR parking spaces is very important in determining travel behaviour for commuting.	
Workplace parking regulation, pricing and cash-out schemes are also likely to influence commuters' travel choices.	A Revealed Preference of sites, in different types of area, where a cash-out option has been implemented could identify their effectiveness in reducing commuter car use.
The small body of existing evidence suggests that a workplace parking levy could potentially be an effective tool for changing behaviour, but is inevitably controversial. Much would depend upon the extent to which employers absorbed the costs rather than passing them onto their employees.	If the introduction of the WPL looks likely to proceed in Nottingham a Revealed Preference study could usefully identify actual responses by employers and employees.
Despite their importance as movement generators, little independent research has been published into the impact of parking policies at stadia.	
Those with higher values of time, such as business passengers, tend to park closer to airport terminals; leisure travellers are prepared to park farther away.	
There is a lack of evidence to demonstrate that parking restraint or charging reduces congestion, though there is a logic that they should do so given the evidence that they potentially impact upon car use.	
There appears to be a tendency for higher price elasticities for congestion charges than for parking fees.	
Few studies directly reported on the impact of parking upon traffic reductions, congestion, modal shift or contributions to reductions in carbon emissions.	
More research is needed into the interaction between sustainable transport measures and parking availability.	
Critics often claim that parking pricing spoils local economic activity by discouraging customers, but it actually provides both economic benefits and costs. It increases turnover of parking spaces which makes finding a space easier, reduces the number of parking spaces required at a location which can provide financial savings, and can reduce traffic problems such as congestion. General levels of provision may affect access modes, in turn, impacting on the quality of the shopping environment.  The precise impact of parking restraint measure upon local economies is difficult to identify.	
It is perhaps surprising that no single model has emerged as the preferred approach in parking research.	
Surprisingly few major studies focussing on the impact of	

parking measures appear to have been undertaken within the UK.	
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Particular research priorities for the short term are highlighted below:

- Investigation of time series analysis of price elasticities of parking charges, and cross-price elasticities with respect to public transport use, and compare these to cross-sectional data, perhaps using a Revealed Preference approach. The aim would be to discover how elasticities vary between different situations and in association with a range of different policy initiatives;
- Survey work with local authorities to determine how parking policy is being adopted into new developments in conjunction with residential travel plans and alternative mobility measures, such as priority bus access, car clubs, and provision for non-motorised transport. The aim would be to understand how focusing on alternatives to mainstream car ownership can influence car ownership and use;
- A study of the parking regimes applied in different areas and their impacts on car ownership levels. The aim would be to better understand the role that parking policies have on aspirations for car ownership and use;
- A study of the impact of car-free settlements upon car ownership and parking behaviour. The aim would be to understand the extent to which car-free settlements actually impact on car-use; and
- A study of the relationship between the provision of car parking at railway stations and the impact on travel patterns. The aim would be to understand the types of stations where greater parking availability should be provided and the circumstances in which it might be reduced.

Such studies would help to develop the evidence base and inform future policy development.

## 1. Background

### 1.1 This commission

This project investigated the impact of different types of parking measures and policies on road traffic, congestion and transport safety, car ownership, on the level of carbon emissions from transport, on the activity of businesses, and on townscapes. The focus was mainly though not wholly, on urban areas. It has involved a systematic review of evidence from original and relevant studies.

The project aimed to support the Department for Transport's (DfT) analytical and modelling capability in terms of improving its understanding of how economic activity is affected by transport investment and interventions such as parking.

For the purposes of this research, policies and measures include pricing (levels, structure and relationship with characteristics of vehicle or user), changes in the supply and location of on-street and off street parking, Park and Ride (P&R), Workplace Parking Levy (WPL), controls on parking provision in new developments, and parking standards in new residential developments. In addition to the intended consequences of parking measures the review also considers what the literature has to say about unintended or perverse consequences.

In undertaking this research we have considered the policy context set by DaSTS<sup>2</sup> which sets out five goals for our transport system:

- to support national economic competitiveness and growth, by delivering reliable and efficient transport networks;
- to reduce transport's emissions of carbon dioxide and other greenhouse gases, with the desired outcome of tackling climate change;
- to contribute to better safety, security and health and longer life expectancy by reducing the risk of death, injury or illness arising from transport, and by promoting travel modes that are beneficial to health;
- to promote greater equality of opportunity for all citizens, with the desired outcome of achieving a fairer society; and
- to improve quality of life for transport users and non-transport users, and to promote a healthy natural environment.

Parking policy could play an important role, in particular in supporting economic growth while reducing greenhouse gas emissions.

### 1.2 Structure of this report

Five sections of the report cover the following:

- Section 2 describes the methodology adopted in the study, highlighting the review process, the journals and papers reviewed, as well as identifying other current research projects that may be of future relevance;
- Section 3 provides an overview of the results of the research;
- Section 4 reports the key results, distinguishing between factors influencing parking at trip origins, destination parking, and research into the impact of parking upon those issues in which the DfT is most interested;
- Section 5 discusses the main findings; and

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<sup>2</sup> Delivering a Sustainable Transport System, Department for Transport, 2008

- Section 6 reports conclusions and recommendations, highlighting the knowledge gaps in parking research that the DfT might consider investigating further.

## 2. Methodology

### 2.1 Review process

A six-stage process was undertaken to identify research papers of possible use, extract useful information, consider their findings and their application to the DfT's concerns:

1. Identification of possible papers from journals, reference books etc by virtue of their title or abstract that suggests that the paper might be of relevance;
2. Review of the paper to investigate whether the research reported is relevant to this study;
3. Identification of other research papers in the references for further analysis;
4. Entering the appropriate details in the Access database;
5. Extraction of other relevant information from the document for use in the final report; and
6. Consideration of the utility of the findings for the DfT, especially the goals set out in DaSTS.

TRL has undertaken a broad approach to selecting the papers for review and have looked wider than those with "parking" in the title or abstract. Thus we have included, for example, papers concerned primarily with car-free settlements and travel planning which are clearly relevant to parking policy, although that may not be their main focus. Furthermore, methodological papers whereby new techniques, or models, that have been developed have also been reviewed.

Several papers cover the technology aspects of parking, for example payment systems that are especially useful for car park operators. These have not been considered in our review.

The methodology applied has been based on adapting approaches used in other policy areas, namely the Rapid Evidence Assessment (REA). The REA is based on the Systematic Review (SR) process, which is a comprehensive methodology for reviewing research evidence that includes a process for assessing the quality and relevance of individual pieces of research. All research evidence (including unpublished "grey" literature) is included in a SR. The REA process is effectively a cut-down version of the SR process where the focus is on published literature that is more readily available. A REA is a simplified and quicker version of a Systematic Review. Given the time constraints on or this project TRL has adopted the REA approach; it has proven difficult to gather significant "grey" literature.

### 2.2 Coverage of review

The term "parking" can be used to describe two factors:

- The **infrastructure** provided for the storage of vehicles whether on or off-street; and
- Parking as an **activity** forming part of the overall process of car travel.

In this study TRL has reviewed research that covers both aspects.

TRL has not excluded papers that were published some time ago – indeed several publications from the 1990's have been reviewed – nor papers that, on first consideration, did not cover the topics of interest. We have excluded most research covering countries other than the UK except where this provided interesting results or issues that merited further consideration. However in our research we have discovered several papers from northern European nations – Germany, Austria, the Netherlands etc - as well some from elsewhere, notably Australia, Hong Kong, Spain and, especially, the USA where these have reported interesting or potentially useful results. These papers have been included in our review since they might be particularly useful in identifying



research gaps in the UK. While journals produced overseas have been investigated, only papers in English have been reviewed in this project.

Research quality is difficult to define. In order to weight different papers we have considered the following criteria:

- Author – known experts are considered to provide more robust evidence;
- Journal of publication – not all transport journals are peer-reviewed;
- Methodology applied – some papers used methodologies that might be considered weak, for example due to small size samples being undertaken;
- Paper length – longer papers are sometimes considered to be more robust providing more detail on the methodology adopted for example, although since many journals have a limit on length this was not applied rigorously. However short magazine articles have not been treated as primary data sources; and
- Professional judgement – TRL's experience in the subject has enabled a ranking system to be applied to research papers.

TRL has therefore avoided including detailed consideration of discussion notes, conference papers, news items etc but has focussed upon academic journals that are peer-reviewed. Nevertheless these secondary sources, as well as unpublished papers, could provide ideas for further research.

While TRL has been able to gather a wide range of papers from electronic sources it has not relied only on this material; many papers reviewed have only been available in paper format via the TRL KnowledgeBase system.

Our aim has been to build an evidence base from published and unpublished research that will be of use to the DfT both in determining future research priorities and in policy discussions.

### **2.3 Other organisations approached**

TRL has contacted the following organisations for further information about their research into parking and to secure copies of papers, especially unpublished research:

- Automobile Association
- British Parking Association
- Chartered Institution of Highways & Transportation
- RAC Foundation

These organisations have provided suggestions for papers to review.

The following consultancies have also been contacted:

- AECOM
- Atkins
- JMP
- MVA
- SDG
- WSP

Unfortunately none of these consultancies have felt able to provide material for the study.

TRL have also spoken to Sheila Holden (STEP Consultancy) who chaired the CIHT working group that prepared the Guidelines on Parking Strategies and Management.

Kent County Council has also provided information regarding their policy development.

## 2.4 Source of papers for review

There is much commentary on parking across a wide range of media; however, much has not been suitable for our purposes. Our approach has involved the review of original research papers and has been targeted at those concerned with the appraisal or evaluation of parking policies and measures that are capable of significantly affecting road traffic and congestion, carbon emissions, business activity and landscapes. In particular, papers concerned with the evaluation of parking measures that have before and after measurement have been sought. This required a significant search process using the TRL KnowledgeBase system.

The 15 journals on which the research focussed are although papers from others were also reviewed=:

- Environment & Planning
- European Journal of Transport and Infrastructure Research
- ICE Proceedings: Transport
- ICE Proceedings: Urban Design
- International Journal of Transport Economics
- Journal of Transport Economics and Policy
- Parking News
- Parking Trends International
- Research in Transport Economics
- Traffic Engineering & Control
- Transport Policy
- Transportation
- Transportation Planning and Technology
- Transportation Professional (formerly Highways & Transportation)
- Transportation Research

In addition, several secondary source and major study documents have also been reviewed:

- *Parking Strategies & Management*, Chartered Institution of Highways & Transportation, 2000
- *Parking Policies and the Effects of Economy and Mobility*, EC COST Action 342, 2005
- *Parking Perspectives: A Sourcebook for the Development of Parking Policy*, Landor, 1997
- *Park and Ride Great Britain: A Survey and Report*, TAS, 2000
- *On-Street parking: A Guide to Practice*, Landor, 1996
- *Parking Policy and Enforcement*, House of Commons Transport Committee and the Government's response, 2006
- *Study of Parking and Traffic Demand*, undertaken for the DfT in 1992 and published in 1997
- *Estimating London's Parking Space Capacity*, undertaken for the DfT in 1997 and published in 2000
- *The Demand for Public Transport: A Practical Guide*, undertaken by TRL for the DfT in 2004

These sources have provided information on other papers that TRL has subsequently reviewed.

Web searches have also been undertaken.

Policy papers have not been included except for *Planning Policy Guidance 13: Transport*<sup>3</sup> (PPG13) that set the basis for maximum parking standards in the UK.

More recently relevant papers have been published in North America and these have been included in the review. While the policy and legislative framework relating to parking in the US differs to that in the UK – for example the provision of parking space is generally “bundled” with accommodation and funded through rents - several papers have been reviewed since they provide a useful, and recent, insight into research activity.

## 2.5 Papers reviewed

TRL identified and reviewed over 175 papers, documents and books of possible relevance to the study and entered their details into the database. Over 160 are referenced in this report. Other important information, focussing particularly upon the research results, has been collated from the papers.

The papers cited in this report are those in which we have confidence in the research methodology undertaken although some are included because they report innovations or interesting results that may be of use.

A list of all papers identified is attached as Annex A.

Nevertheless no doubt there are other papers that we have been unable to access and review for this study.

## 2.6 Additional parking research

In undertaking this project TRL has uncovered new research projects into parking issues that are being undertaken within universities. We have identified five that will be reporting in the future:

- *Analysing and prioritising effective sub-national government mechanisms to reduce greenhouse gas emissions from road transport:* This project is being undertaken at Oxford University and, in part, by the British Parking Association. It is due to be completed in September 2010. This research is an international comparative study assessing the effectiveness of various policies implemented by a variety of sub-national state governments, in terms of their ability to reduce the climate impacts of transport - specifically cars. The main objective of the study is to investigate the internal frameworks, interplay and dynamics at the state government level, both between departments which construct and govern these specific policy areas, but also between the areas of responsibility between levels of government. The role of the private sector in these decision making processes is also examined. The main hypothesis of the research is that there is a disparity between environmental/climate change policy and transport policy which causes these policy interventions to be ineffectual. Without successfully linking frameworks and stakeholders in the process, tangible emissions reductions will be difficult to achieve. Parking policies form a subset of those under scrutiny. Case studies looking at issues of governance in this area in Bavaria, California, Scotland and South Australia are being considered.
- *Modelling of the role of tax concessions in promoting uptake of low carbon cars in the UK:* This research is being undertaken by the University of the West of England.

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<sup>3</sup> Planning Policy Guidance Note 13: Transport (PPG13), CLG/DfT, 2001

- *An examination of whether older people's attitudes to road pricing are different from the ones of other age groups:* This project is also being undertaken by the University of the West of England. At the moment there are significant research gaps in assessing the causal relationship between older age and road pricing.
- *The Impacts of Civil Parking Enforcement (CPE) by Local Authorities:* The objective of this research is to identify the various components of a successful parking policy and enforcement regime and produce a toolkit that will enable a local authority to judge whether their parking policy and enforcement regime is effective. It involves the investigation of data and the information available to help inform the impact of CPE and the behaviours by civil parking enforcement authorities in relation to delivering an effective and well regarded parking enforcement regime. The research is funded by the DfT and the expected completion date is May 2010.
- *Off-Street Parking Policy Without Parking Requirements: a Need for Market Fostering and Regulation:* This research by Paul Barter addresses and extends the recent upsurge of interest in market-oriented reform of parking policy. The research is investigating additional barriers to the emergence of off-street parking markets and several likely problems within them. Rather than suggesting the rejection of market-oriented parking policy, the research findings are taken to imply a need for a more vigorous policy effort than has so far been called for. Achieving well-functioning off-street parking markets would require efforts both to actively foster such markets and to regulate to ensure their health. Deregulation would not be enough.

Results from these studies may be of future interest to the DfT.

### 3. Overview of results

#### 3.1 General

The main area of interest for the DfT is the impact of parking policy upon the following factors:

- Traffic and congestion
- Carbon emissions
- Sustainable transport
- Urban design
- Business activity and town centre viability
- Landscape and townscape
- Event planning
- Role of technology

These issues are covered in this report.

Many research papers have been published that relate to parking, albeit often indirectly or as part of a study that is investigating other issues e.g. road-user charging. In many there is little detailed consideration of the issues in which the DfT is particularly interested. Nevertheless potential topics for future research are generated from such papers. Furthermore the papers reviewed have enabled TRL to build up a broad evidence base of useful information.

Much guidance and advice on parking operations is provided to car park operators, developers and local authorities, e.g. *On-Street Parking: A Guide to Practice*<sup>4</sup>. These reports often cover a range of operational issues including legislation, design, and undertaking surveys. Others, e.g. *Planning Policy Guidance 13: Transport*<sup>5</sup> and *Parking Strategies & Management*<sup>6</sup>, set out the main policy considerations that should guide local authority decisions. Furthermore, the DCLG/DfT *Manual for Streets*<sup>7</sup> considers designers' and local authorities' approach to residential street design and helps change it for the better. TRL has reviewed some of these documents primarily in order to identify other publications that provide research results of interest to our inquiry.

Studies are almost exclusively concerned with city and town centres, with little consideration given to rural areas. However many studies are concerned with how access to town centres is affected by parking policies which clearly impacts upon rural communities.

Several papers address parking matters at the national scale, for example policy measures. Some studies cover relatively small geographic areas however, sometimes only being concerned with the situation in a few streets; others are concerned with a single town. The replicability of these results elsewhere and their interpretation may be limited.

Some papers have a particular focus such as airport parking e.g. *Car Parking Management at Airports: A Special Case*<sup>8</sup>, or match-day parking restrictions around stadia e.g. *Watford Match Day Parking Scheme*<sup>9</sup>. Perhaps surprisingly there appears to be few papers covering such specialist parking topics.

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<sup>4</sup> *On-Street Parking: A Guide to Practice*, C Chick and P Cunningham, Landor Publications, 1996

<sup>5</sup> *Planning Policy Guidance Note 13: Transport (PPG13)*, CLG/DfT, 2001

<sup>6</sup> *Parking Strategies & Management*, Chartered Institution of Highways & Transportation, July 2005

<sup>7</sup> *Manual for Streets*, CLG/DfT, 2007

<sup>8</sup> *Car Parking Management at Airports: A Special Case*, Alridge, Carreno, Ison, T Rye and Straker, Transport Policy, 2006

<sup>9</sup> *Watford Match Day Parking Scheme*, A Thomas, ICE Transport Proceedings, 2003

Several papers are theoretical studies, for example focussing on stated preference results rather than behavioural change that has occurred as a result of the implementation of new parking arrangements. Reviewed studies include those that relate to the public acceptability of controversial policies such as the introduction of workplace parking levies e.g. *Acceptability of WPL is Cause for Concern*<sup>10</sup>.

Other studies are descriptions of how studies should be conducted e.g. *the Hong Kong Parking Demand Study*<sup>11</sup>.

Many of the more relevant papers reviewed were published some time ago – notably during the 1990's. As a result the results and conclusions may not necessarily be relevant to current circumstances. Nevertheless with the continuing rise in car ownership it seems likely that the impact of parking on congestion and related consequences may be much greater.

Research may have been hindered by the lack of statistics on the availability of parking<sup>12</sup>, especially that related to Private Non-Residential (PNR) parking – over which local authorities have limited controls<sup>13</sup>. According to this report for the DfT apparently "*no one seems to know how much parking space of different types there is*". This should form the starting point for understanding the relationship between supply and demand and perhaps more research is needed in this area.

Two types of information source are commonly applied in research:

- Cross sectional – comparing the travel responses of different individuals or groups at a single point in time to make inferences about behaviour; and
- Time-series – using direct observations of such behaviour over a period of time.

Most studies have focussed on cross-sectional studies and the picture of behavioural change over time with respect to parking policy is unclear.

### 3.2 Types of parking

Parking research in the literature may be categorised generally as focussing on origins and destinations.

Research at origins considers a range of issues including uncontrolled and controlled parking, parking management methods, such as e.g. Controlled Parking Zones (CPZs), Residential Parking Zones (RPZs). Research also considers parking availability and standards at existing and new private residential developments and car-free settlements etc.

The types of parking to be found at origins vary:

- Private off-street parking;
- Public off-street parking (short stay, long-stay, contract);
- Controlled (paid) on-street parking; and
- Uncontrolled (free) on-street parking.

Destinations may be categorised in a variety of ways; the following approach has been adopted for this research:

- General town centres (including P&R and controlled (paid) on-street parking);
- Railway stations;
- Shopping centres;
- Workplaces - Private Non-Residential (PNR) parking;

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<sup>10</sup> Acceptability of WPL is Cause for Concern, S Ison, J Thorne, S Wall, Traffic Engineering & Control, 2000

<sup>11</sup> The Hong Kong Parking Demand Study, W lam, R Fung, S Wong, C Tong, ICE Transport Proceedings, 1999

<sup>12</sup> Parking Perspectives: A Sourcebook for the Development of Parking Policy, M Valleley with R Garland, P Jones, A Macmillan, Rees Jeffries Foundation, Landor Publications, 1997

<sup>13</sup> The Effect of Parking Policies in England: Stage 1 Final report, Atkins for DfT, 1996

- Stadia; and
- Airports.

A series of research questions has been formulated for each aspect and a conclusion reached. Possible research “quick wins” are also identified. While there is overlap in the applicability of the research reviewed, wherever possible TRL has identified differences in outcomes.

## 4. Reviewed Research results

### 4.1 Introduction

The importance of parking within transport policy is often understated. However *"the fact that cars typically spend 95% of their lives parked somewhere means that finding a place to park a car is potentially of greater importance than concern over a lack of available road space to accommodate it while it is moving"*<sup>14</sup>. This assumes, of course, that a car is used on average for only one hour a day despite, generally, being available for use at any time.

Furthermore responsibility for parking is often fragmented: in two-tier authorities while County Councils have responsibility for transport policy along with strategic planning, parking comes within the purview of District Councils as does the granting of planning permissions. Only within Unitary Authorities are these responsibilities unified. 354 local authorities (district and unitary councils) outside London have taken powers to control parking via Civil Parking Enforcement (CPE).

Parking management measures typically operate in two ways (according to Feeney<sup>15</sup>):

- Changing the level or structure of parking charges; and
- Changing the supply of parking spaces.

Motorists can respond by:

- Changing the location of where they park;
- Changing the start time for the trip;
- Changing the mode used;
- Changing their destination; or
- Abandoning the trip.

### 4.2 Parking Provision at Origins

#### **Research Question 1**

The availability of parking potentially affects car ownership levels and travel choice. What current research exists to assess the effectiveness of parking standards and measures introduced at origins?

#### **4.2.1 Policy background**

According to Haworth and Hilton<sup>16</sup>, post-war planners put forward imaginative and detailed proposals for housing, highways and large-scale intersections with seemingly little thought for the provision of parking facilities. Legislation introduced in 1947 required local authorities to adopt standards of parking provision for development control. Parking standards were then increased from 1960 when they were related to land use.

However, since the publication of PPG13: Transport<sup>17</sup> initially in 1994 but significantly revised in 2001, there have been maximum standards for residential parking. Planning Policy Statement 3: Housing<sup>18</sup> requires that parking policies are not to be expressed as minimum standards and required that local planning authorities *"should, with stakeholders and communities, develop residential parking policies for their areas, taking*

<sup>14</sup> Parking Perspectives: A Sourcebook for the Development of Parking Policy, M Valleley with R Garland, P Jones, A Macmillan, Rees Jeffries Foundation, Landor Publications, 1997

<sup>15</sup> A Review of the Impact of Parking Policy Measures on Travel Demand, B Feeney, Transport Planning and Technology, 1989

<sup>16</sup> Car Parking Standards and the Urban Economy, S Haworth and I Hilton, Traffic Engineering & Control, 1982

<sup>17</sup> Planning Policy Guidance Note 13: Transport (PPG13: Transport), CLG 2001

<sup>18</sup> Planning Policy Statement 3: Housing (PPS3: Housing), CLG, 2006



*account of expected levels of car ownership, the importance of promoting good design and the need to use land efficiently."*

PPG13: Transport argues that *"The availability of car parking has a major influence on the means of transport people choose for their journeys. Some studies suggest that levels of parking can be more significant than levels of public transport provision in determining means of travel (particularly for the journey to work) even for locations very well served by public transport. Car parking also takes up a large amount of space in development, is costly to business and reduces densities. Reducing the amount of parking in new development (and in the expansion and change of use in existing development) is essential, as part of a package of planning and transport measures, to promote sustainable travel choices."* Furthermore *"maximum standards should be designed to be used as part of a package of measures to promote sustainable transport choices, reduce the land-take of development, enable schemes to fit into central urban sites, promote linked-trips and access to development for those without use of a car and to tackle congestion."*

#### **4.2.1 The nature and value of residential parking**

In the UK cars may be parked at residences either off-street in garages or forecourts, or on-street.

In a nation-wide survey of 500 principal drivers in 2005 (i.e. mainly car owners who regularly drive) the RAC<sup>19</sup> (representing motorists) reported that 73% of cars are parked off-street at night – either in a garage (26%) or in a drive or communal parking area (47%). This will clearly vary in different areas. Parking at older terraced houses will be on-street, while that at detached properties is more likely to be off-street. Even amongst single person households, who might be expected to live in areas where off-street parking is less likely to be available, 60% of cars were parked off road. Over the previous seven years, the usage of garages had fallen from 28% to 24%, despite the construction of more houses with garages, with more drivers now choosing to park their car outside.

Meanwhile, the same survey found that a parking space will typically add around 8% to the value of a property, while a single garage will add a further 3%, and a double garage a further 9%.

However, at the same time, people appeared unwilling to pay directly for parking. When asked what price they would pay to secure parking outside their homes per year, more than half those surveyed would not pay anything; only 2% would pay over £500.

In the early 1990s, Balcombe and York undertook two surveys examined the views of households in a variety of residential areas and also from a sample of local authorities<sup>20</sup>. One of the questions put forward to residents comprised of valuing a parking space. Although the answers were hypothetical, the findings reported that between 33 – 50% of car owners would be prepared to pay up to £50 annually for an on-street space. One of the conclusions from the study was that pricing mechanisms alone were unlikely to level demand.

(Willingness to pay at destinations, and to some extent at origins, is covered in detail in sections 4.3.2 and 4.3.3).

The implications, then, are somewhat contradictory – the data on house prices highlights that people value parking spaces, though stated willingness to pay indicates that people rarely see this as something that they should be directly charged for.

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<sup>19</sup> Parking in Transport Policy, RAC, 2005

<sup>20</sup> The Future of Residential Parking, R Balcombe and I York, 1993

#### 4.2.2 Parking Standards for residential properties

##### Research Question 2

Is there research to demonstrate that the imposition of maximum parking standards has a benefit in reducing car ownership and hence use?

Regulating and managing parking space, using parking standards, is seen as a way of maintaining the balance between supply and demand, not only for parking, but also as a way of regulating the demand for road space (*Parking Perspectives*<sup>21</sup>). One of the problems is the lack of statistics on the amount of parking supply. According to *Parking Perspectives*, it is within the parking system that the effects of management strategies using different combinations of four management instruments: location; quantity; access; and price – will be most directly felt. (This is a refinement of the classification used by Feeney<sup>22</sup>). It is often the case that the objectives which parking policy is asked to meet are in conflict.

Most on-street parking is unpriced and unmanaged by local authorities. However the expansion of management schemes such as Controlled Parking Zones (CPZs) and Residential Parking Zones (RPZs) has led to interest into their impacts.

Major restrictions on parking in high-density residential areas might persuade some residents to abandon car ownership simply because they have nowhere convenient to leave their vehicle. Parking may be limited by various means: these could include bans on on-street parking, or enabling on-street parking during certain time periods. In addition, land use planning controls might be used to restrict the numbers and locations of off-street parking places.

In a review of north American evidence<sup>23</sup>, Shoup discussed the relationship of parking requirements and parking demand. He stated that by reducing the market price of parking, minimum parking standards effectively offer subsidies and this in turn inflates the demand which is often used to set parking standards. Shoup argued that in the USA regulations had been established for peak periods of demand often using a small number of case studies in suburban areas which offered little or no public transport provision. One of the central elements highlighted within this research is the lack of information and literature on the cost of a parking space. While in the UK maximum parking standards have been introduced this is relatively recent. Prior to the publication of PPG13 minimum parking standards were common, for example in Hertfordshire where they were based on the number of bedrooms in a property – with about one space to be provided for each bedroom.

Another literature review, undertaken by Litman<sup>24</sup> and supported by his own arguments, suggested that optimal parking supply is the amount that motorists would purchase if they paid all costs directly, including externalities, and had good parking and transport options. But planning practices in the USA often reflect an assumption that it is desirable to maximise parking supply and minimise user charges. Parking management may be seen therefore as a measure of last resort, to be applied only where it is infeasible to expand supply.

Efficiency-based standards take into account geographic, demographic and economic factors that affect parking demand. They also reflect the relative costs and benefits of different options, so less parking should be available where parking supply is relatively costly to provide or where management programmes are easy to implement. Efficiency-

<sup>21</sup> *Parking Perspectives: A Sourcebook for the Development of Parking Policy*, M Valleley with R Garland, P Jones, A Macmillan, Rees Jeffries Foundation, Landor Publications, 1997

<sup>22</sup> *A Review of the Impact of Parking Policy Measures on Travel Demand*, B Feeney, Transport Planning and Technology, 1989

<sup>23</sup> *The High Cost of Free Parking*, D Shoup, Journal of Planning Education and Research, 2005

<sup>24</sup> *Parking Management: Strategies, Evaluation and Planning*, T Litman, Victoria Transport Policy Institute, 2008

based standards should also reflect strategic planning objectives such as a desire for more compact developments, or to reduce traffic levels.

Given the value that is potentially placed on parking spaces, the policy of having maximum parking spaces is somewhat controversial. Both Shoup and Litman highlighted that minimum standards can result in inefficient provision, and, by implication, encourage car ownership. However, the counterargument is that the demand for parking is led by variables other than parking supply, such that maximum standards can result in spill-over, fly parking and general conflict. For example White<sup>25</sup> argued that maximum parking standards are counter-productive since they fail to take account of residents' aspirations for car ownership identified in local surveys.

There are a number of research reports that support the latter view.

Research in the early 1990's considered the impact of growing car ownership and available residential parking space through a series of interviews with local authority officers in the UK<sup>26</sup>. One of the key findings of this research (undertaken for the DfT) was that the determination of people to own cars outweighed all other considerations, which included the difficulty to park.

In the RAC survey<sup>27</sup> cited above, when asked what actions people would consider taking if they had no access to parking outside their homes, 29% said they would consider moving house. Almost two-thirds of people would consider converting their garden into parking if their residential parking space was "threatened" i.e. removed or banned from the road outside their property; this would have obvious implications for the local street environment and could also reduce parking space availability for the occasional user.

CABE – the Commission for the Built Environment, undertook in-depth, face-to-face interviews<sup>28</sup> with a random sample of residents, supplemented with a focus group at each development. In total, 241 residents from 11 new development schemes in the UK (20 per cent of residents in total) were asked to give their views on the places where they lived. The most controversial aspect of new developments for the residents was the design of the streets and the provision of car parking. Only 46% of respondents scored the layout of car parking as good or very good. Apparently this was often less about the design of parking and more about the level of provision, which was felt by most people to be inadequate for the scale of car ownership and demands for visitor parking. Attempts to restrict parking spaces as a means of curbing car ownership were felt to be unrealistic and to have little or no impact on the number of cars a household would acquire.

A comparison<sup>29</sup> of parking standards with other land-use measures in encouraging public transport use also indicated that they are not as effective as other interventions: corridor developments and commuted payments (for parking).

However, as calculated, for example, in DCLG, based on 2001 Census data, the type of location affects typical car ownership, with residents in areas which are less likely to have high levels of parking provision exhibiting lower levels of car ownership.

Moreover, the popularity of places where parking provision tends to be limited (such as the historic towns, or older, central parts of cities) highlights that ability to park is only one factor that people value about where they live, and other factors – such as the quality of the environment or the availability of public transport – may be more important in housing choice. In some cases, extensive parking provision is clearly at odds with generating a compact, walkable local network.

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<sup>25</sup> The Case Against Maximum Standards for Residential ("Origin") Parking in Areas Without On-Street Parking Controls, R White, Unpublished, Kent CC, 2009

<sup>26</sup> The Future of Residential Parking, R Balcombe and I York, TRL, 1993

<sup>27</sup> Parking in Transport Policy, RAC, 2005

<sup>28</sup> What It's Like To Live There: The Views of Residents on the Design of New Housing, The Commission for the Built Environment, 2005

<sup>29</sup> The Demand for Public Transport, R Balcombe (Editor), TRL, 2004

One example of linking parking standards to other aspects of the transportation networks was reported by Carson *et al*<sup>30</sup>. Focussing on Wycombe, the area also included Marlow and Princes Risborough. Five accessibility bands were defined, ranging from good to poor public transport. These were used to define both residential and non-residential parking standards to guide development control decisions. It also set the requirements for developer contributions. In this way accessibility measures could be used to determine different levels of parking provision based on accessibility by other modes, notably public transport.

Meanwhile, the development of initiatives such as car free developments and residential travel plans indicates that there is professional interest and belief that it is possible to influence car ownership through parking provision.

Following a household survey reported by Maat *et al*<sup>31</sup> (*Influence of the Residential and Work Environment on Car Use in Dual-earner Households, 2009*) the authors concluded that compact urban forms are more favourable for public transport because of their larger customer base, while owning and using a car is more expensive and more difficult in urban areas owing to congestion and parking problems.

Mukhija and Shoup<sup>32</sup> argued that planners could use the following five strategies to improve urban design.

1. Deregulate or limit the number of parking spaces.
2. Improve the location of parking.
3. Improve the design of surface parking.
4. Improve the design of parking structures.
5. Improve the design of residential garages.

Recent research undertaken by the DfT<sup>33</sup> reported that, in general, people with parking restrictions in their locality felt positive about them: 61% disagreed or strongly disagreed with the statement "*parking restrictions in my local area cause problems for me*". The majority, 80% recognised the importance of controls and agreed or strongly agreed that "*parking restrictions are there for a good reason*". People were more divided about the statement "*parking restrictions are mostly there to make money*" – 35% agreed or agreed strongly, and 44% disagreed or disagreed strongly.

A particular problem in some areas is pavement parking. Little research has been undertaken into this although according to one study<sup>34</sup>, pavement parking is considered an issue by local authorities. However there seemed to be a lack of enforcement since authorities appeared not to be applying Traffic Regulation Orders (TROs) due to their perception of the difficulty of enforcement against what may be a transient problem.

Surveys in Kent<sup>35</sup> of relatively small numbers of residents of recently-constructed housing, appeared to confirm long term anecdotal evidence concerning the parking problems experienced by residents where restraint on parking spaces and/or street space had been applied. Parking provision appeared not to be satisfying residents' aspirations for car ownership. In response to these problems, Kent County Council, in partnership with district council planning authorities, had adopted residential parking guidance that differentiates between areas of on-street controls and those where controls are considered to be inappropriate. For the former, maximum amounts are suggested, while for the latter, minimum amounts were recommended, taking into

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<sup>30</sup> Encouraging Sustainable Development by Linking Public Transport Accessibility, New Parking Standards and Developer Contributions, G Carson, M Dix, J Callaghan and R Slevin, Traffic Engineering & Control, 1999

<sup>31</sup> Influence of the Residential and Work Environment on Car Use in Dual-earner Households, K Maat, H Timmermans, Transportation Research Part A 43, 2009

<sup>32</sup> Quantity versus Quality in Off-Street Parking Requirements, V Mukhija and D Shoup, Journal of the American Planning Association, Vol. 72, No. 3, Summer, 2006

<sup>33</sup> Public Experiences of and Attitudes Towards Parking, DfT. 2009

<sup>34</sup> Pavement Parking Research, MVA for DfT

<sup>35</sup> Residential Parking Briefing Note, Kent CC, 2009

account residents' desires for car ownership. Both approaches put good design at the forefront, along with efficient use of land.

According to Kent CC the non-use of garages causes particular problems, as does the unwillingness to use tandem driveways. In both cases, many residents are prepared to park awkwardly on street, causing difficulties for pedestrians and other street users and creating cluttered scenes in otherwise attractive developments. Similarly, parking courts that involve vehicles being further from property entrances than useable street space are often under-utilised. Many developments are so cluttered with residents' cars that visitors find it difficult to park. Visitor parking bays are seldom managed to prevent them from being monopolised by certain residents.

Increasingly, works vans are being parked overnight in residential areas. Covenants intended to prevent this happening are seldom, if ever, enforced. Similarly, residents' agreements concerning where people will, and won't, park are seldom acted upon, especially when the streets in question are public highways. A study of the variation in ownership showed that this was far greater for smaller dwellings. Developments with maximum parking provision based on the '1.5 maximum per unit' limit for 2 and 3 bedroom dwellings were particularly susceptible to problems apparently.

Kent's evidence quoted residents to suggest that well-designed and demand-aware parking provision would not encourage higher levels of car ownership. Where parking controls were not in place, ownership levels did not appear to be related to the amount of parking space available. Furthermore, public transport provision, and use, did not appear to have a direct effect upon car ownership. According to Kent CC the 'day one' provision of free bus use in one development led to high levels of uptake without strong suppression of car ownership, while the delayed introduction of bus services in another development area generated parking behaviour that compromised the planned routes.

Kent CC argued that it is now apparent that good street materials, frontage enclosure and strong architecture can override any negative aspects of street widths. As such well designed streets with more (attractively designed) space for parking can look much better than narrower streets cluttered with ad hoc parking.

### **Conclusion**

Research on parking standards is limited – and surveys which ask people about the flexibility of their current behaviour will potentially produce very different results to those which look at longer term trends, or revealed behaviour based on where people are living.

### **Quick Win**

Undertake some research with local authorities to consider before and after effects of larger scale new developments to determine whether parking standards implemented and alternative mobility measures have influenced travel patterns?

### **4.2.3 Alternative approaches to residential parking**

**Car free settlements:** Although considered a relatively new phenomenon, many authorities are interested in car-free settlements within which parking is prohibited. Accommodation is often provided for those in low-car owning groups such as the elderly. There is no precise definition of a car-free settlement although generally residents must agree not to have a car. However often vehicles are parked on-street within or near to developments that are described as car-free.

### **Research Question 3**

Does the research indicate that car-free settlements reduce the demand for car parking or that residents simply park elsewhere?

Research which has reviewed the progress of car-free housing in both Europe and the UK reports that European projects encompass mobility incentives which include improved public transport and green spaces on a larger scale (see Morris<sup>36</sup> and Morris *et al*<sup>37</sup>). In comparison, the UK sites examined often adopt a 'do minimum' approach, lacking alternative mobility measures. Car-free housing is often located within small scale infill developments. This offers little incentive to potential residents not to purchase a car and is likely to be a less effective means of promoting the concept of car-free living. However, the concept is still developing, and further evidence about such developments is still required.

Resistance from developers may be their belief that the urban housing market requires layouts that are dominated by the need to provide parking and access for vehicles. Community travel plans offer the potential to consider activity patterns more holistically both in terms of living space and access to trip attractors for work, healthcare, education or leisure purposes.

The Beddington Zero-Emission Development (BedZED), within the London Borough of Sutton, forms one of the car free settlements reviewed by Morris<sup>38</sup>. It supports 82 homes, 16 business units and incorporates energy efficient design. The project appointed a Green Lifestyles Officer to implement a green transport plan and to address issues of overspill parking. The residential parking standard is reported as 0.85 per unit which exceeds standards set by European car free settlements and may be considered to be rather high for what is supposed to be a car-free settlement.

### **Conclusion**

Travel plans could be used to help mainstream the car-free concept within the UK making it more attractive to both developers and potential residents with benefits in terms of reduced parking needs. Currently, in car free developments, it seems that improvements in other modes of transport and the provision of green space have not always reached the levels which are seen as necessary to make such developments successful.

### **Quick win**

Research might investigate the changes to other modes of transport that have accompanied the development of car-free settlements.

**Residential Travel Plans and Car Clubs:** These are designed to help manage parking in residential complexes and reduce car use<sup>39</sup>. They often feature the introduction of a car club and improved non-car travel options.

### **Research Question 4**

Does the research show that RTPs (especially Car Clubs) reduce parking space provided and hence car ownership and use?

<sup>36</sup> Car-Free Development: the Potential for Community Travel Plans, D Morris, Universities Transport Study Group, 2005

<sup>37</sup> Car-free Development Through UK Community Travel Plans, D Morris, M Enoch, D Pitfield and S Ison, ICE Proceedings Urban Design and Planning 162, 2009

<sup>38</sup> Car-Free Development: the Potential for Community Travel Plans, Morris, Universities Transport Study Group, 2005

<sup>39</sup> Making Residential Travel Plans Work: Good Practice Guidelines for New Development, DfT, 2005

An element of RTPs which has received recent attention is the role of Car Clubs. Nationwide, Car Clubs have grown from 32,000 members in 2007 to 64,000 in December 2008 to 113,000 in January 2009. In 2008/9, an annual survey of Car Clubs users<sup>40</sup> found that 39% of respondents reduced the number of vehicles they owned after joining the scheme and that, compared to a non Car Club motorist, an average Car Club member travels somewhere between 13 – 62% less by car. This has implications for emission reductions across the UK. Furthermore, about a quarter of members and joiners to Car Club programmes reported that they would have purchased a new car had they not joined a Car Club. The development of Car Clubs is still in its infancy and although the potential to reduce vehicles, and emissions, is not yet fully understood, it is clearly an area that requires further investigation from a policy implementation aspect. (Since the 2009 research on car clubs was published, a further report has recently been published, reporting broadly similar results – i.e. that car clubs result in substantial reductions in private vehicle ownership, and car club members drive relatively low mileages<sup>41</sup>).

In some locations, Car Clubs are being developed to provide access to vehicles without the concomitant problems of providing significant parking space and increasing local congestion. However an emerging issue is the importance of getting Car Clubs planned into new residential development at the beginning, so that they are put in 'prime spots' - i.e. the most convenient spaces, where people easily see them - rather than being introduced as an after-thought at the end of the planning process, when they tend to be much less well-located. This makes a difference to how successful they tend to be and the extent to which they are seen as an alternative to private car ownership. However this area has not been fully researched.

#### **Summary of section 4.2**

- Differences in house prices indicate that people value parking, although surveys suggest that they may be very unwilling to pay for it directly.
- There are a number of surveys suggesting that people's desire to own a car will not be affected by parking provision, though analysis of different types of locations suggests the opposite conclusion.
- Car free settlements, residential travel plans and car clubs offer new ways of addressing car ownership and car parking provision, though all are relatively embryonic initiatives.
- There are conflicting messages from experience abroad. The US still favours minimum parking standards, though there are a number of US critics of this approach, who argue that it encourages car ownership and use.
- In general, the literature on this topic is remarkably limited, often dated, and rarely focuses on all dimensions of interest.

#### **Conclusion**

Little research exists on the effectiveness of types of demand management measures in residential areas, particularly with regard to longer term impacts. Car Clubs potentially offer an exciting new opportunity to reduce car ownership in densely populated areas.

#### **Quick win**

More assessment of the impacts of CPZs and RPZs in relation to the prices that people are willing to pay, and the way that such policy initiatives impinge on car ownership would be beneficial. This would complement the study by Balcombe and York<sup>42</sup>.

<sup>40</sup> Carplus annual survey of car clubs 2008/09, D Myers and S Cairns, 2009

<sup>41</sup> Carplus annual survey of car clubs 2009/10, C Harmer and S Cairns, 2010.

<sup>42</sup> The Future of Residential Parking, R Balcombe and I York, TRL, 1993

### 4.3 Parking availability at Destinations

Three particular parking-related features affect the destination of a car journey:

- The availability of parking spaces;
- The cost of parking; and
- The location of parking spaces in relation to the desired final destination.

This section reflects these distinctions.

#### 4.3.1 The availability of parking spaces

##### **Research Question 5**

Does the research indicate how activity patterns, parking supply and transport demand measures interact to determine availability of parking space at destinations?

About a third (31%) of car drivers and passengers in a recent DfT survey<sup>43</sup> said they had no problems with the availability of parking. Some 38% said parking availability caused problems when visiting a hospital, 30% said it was a problem when going shopping and 21% said it was a problem when they made trips for personal reasons (e.g. going to the bank or the doctor).

An international review<sup>44</sup>, combined with discussions with key organisations, reported that the focus on city centres (Central Business Districts) has been of parking restraint given that these areas are where (peak period) traffic congestion has been highest and a viable transport alternative (mostly public transport) is generally available. In addition, parking restraint has focused on commuters as this group make up the majority of peak period travellers.

Evidence from surveys of office development in London, quoted by Acutt<sup>45</sup>, showed that the provision of car parking is a significant factor in the choice of transport to work (Department of the Environment and Department of Transport, 1993). As with parking charges, the impact of car parking restrictions on total car use and fuel consumption might be ambiguous. Public transport use is, however, likely to increase.

Simulation studies in the UK, also cited by Acutt and Dodgson, showed that halving parking spaces in central areas of cities would be even more effective than doubling charges in reducing car use and increasing traffic speeds. Parking policy is viewed as both an economic and a regulatory instrument. Economic approaches are seen as being effective complements to regulatory instruments. Nevertheless the authors argue that major restrictions on parking in high-density residential areas might persuade some residents to abandon car ownership.

The availability of parking — and hence both the ownership of cars and the frequency of car use — is the most significant influence on car mileage, according to a household survey undertaken in the US<sup>46</sup>. This survey involved 1113 adults in the San Diego and San Francisco metropolitan area. Chatman argued that more dense developments would not influence travel much unless road level-of-service standards and parking requirements were reduced or eliminated. The table below highlights the impact that withdrawing available parking has on journey time by lengthening trips. While walking

<sup>43</sup> Public Experiences of and Attitudes Towards Parking, DfT, 2009

<sup>44</sup> International Approaches to Tackling Transport Congestion, Booz Allen Hamilton, 2006

<sup>45</sup> Controlling the Environmental Impacts of Transport: Matching Instruments to Objectives, M Acutt and J Dodgson, 1997

<sup>46</sup> Deconstructing Development Density: Quality, Quantity and Price Effects on Household Non-work Travel, D Chatman, Transportation Research Part A 42, 2008



and transit journeys are unaffected, car users experience longer travel times as a result of the withdrawal of parking spaces (see table 1 below). However the increase cited in this example only affects the use of cars for local trips, and even then the travel time taken by car is less than or remains the same as the alternatives. This finding suggests the importance of the effects of the built environment on the inconvenience, or otherwise, of cars — in this case, parking search time and/or monetary cost, rather than slower road speeds.

**Table 1: Example trip cost (min) before and after decrease in local parking availability**

Mode/distance	Before	After
Auto/local	5	15
Auto/regional	15	15
Walk/local	15	15
Walk/regional	60	60
Transit/local	20	20
Transit/regional	35	35

Lois and Lopes-Saez<sup>47</sup> undertook an opinion survey of 284 people in Spain to understand the psychosocial perspectives of car users. They argued that the more time people needed when using public transport, the more they are inclined to use the car to travel to work. By contrast, the more time spent parking near the workplace, the lower the probability of travelling by car to work. The variable 'in-car time' is not significant i.e. more or less in-car time is not as influential compared with parking time or the time on public transport.

In contrast, Litman<sup>48</sup> argued that the total impacts of *parking management strategies* are multiplicative not additive i.e. as the strategy to include more mutually supportive elements so the benefits increase more rapidly. Most parking management strategies have modest individual impacts, typically reducing parking requirements by 5-15%, but their impacts are cumulative and synergistic. A comprehensive parking management programme that includes an appropriate combination of cost-effective strategies can usually reduce the amount of parking required at a destination by 20-40%, while providing additional social and economic benefits. Shared parking reduces the parking requirements by 10%, to 90% of the original level.

Finding a parking space is a deterrent to car use, but not necessarily an encouragement to the use of alternative modes. The RAC<sup>49</sup> reported that 29% of principal motorists have given up their journeys and gone home because they couldn't find a parking space on at least one occasion. Transportation Demand Management (TDM) typically combines a variety of techniques which aim to induce modal choice behaviour changes that reduce the demand for SOV (Single Occupancy Vehicle) trips and parking through encouraging the use of alternative modes e.g. public transport. In addition, TDM programmes can therefore help reduce parking demand through incentives and disincentives.

According to the Metropolitan Transportation Commission in California<sup>50</sup> minimum parking requirements may result in an oversupply of parking and can create a "dead zone" of empty parking spaces in the middle of a commercial district or neighbourhood. An oversupply of parking can result in more car use, lower site density, higher land use

<sup>47</sup> The Relationship Between Instrumental, Symbolic and Affective Factors as Predictors of Car Use: A Structural Equation Modelling Approach, D Lois and M Lopes-Saez, Transportation Research Part A 43, 2009

<sup>48</sup> Parking Management: Strategies, Evaluation and Planning, T Litman, Victoria Transport Policy Institute, 2008

<sup>49</sup> Parking in Transport Policy, RAC, 2005

<sup>50</sup> Developing Parking Policies to Support Smart Growth in Local Jurisdictions, Metropolitan Transportation Commission in California, 2007

consumption, lower land values and less use of alternative travel modes. Although a US based finding, there are parallels with out of town retail parks seen throughout the UK.

Litman<sup>51</sup> reported that conventional parking standards in the USA are intended to ensure that parking is abundant and cheap; reflecting a subsidy of driving and a stimulation of urban sprawl. This analysis of LEED (Leadership in Energy and Environmental Design) requirements found that conventional parking standards are often based on the 85th percentile (resulting in a situation whereby 15 out of 100 spaces will never fill even during peak periods), and lack adjustments to reflect geographic, demographic or management factors that reduce parking demand. These practices tend to stimulate car ownership and use (by effectively subsidising car travel), and sprawl (by increasing the amount of land required for parking facilities). These impacts are large. According to Litman, free parking tends to increase traffic and associated costs (traffic congestion, accidents, energy consumption, pollution emissions, etc.) by about 20% compared with charging motorists directly for the parking facilities they use; more efficient parking management can significantly reduce parking requirements, vehicle travel and sprawl, and the various associated costs, providing significant sustainability benefits.

Parking requirements alone do not create car dependency according to Manville and Shoup<sup>52</sup>. But parking requirements have often generated land use patterns that might otherwise not have arisen, and they have channelled significant funding and land toward providing for the car. Some of that money and land might have been put to better use. Apparently "In American cities, close to half of all the urban space goes to accommodate the automobile; in Los Angeles, the figure reaches two-thirds." More than one-third of the Los Angeles region, could be accounted for by streets, driveways, parking lots, and freeways. Other evidence they cite states that from 1930 to 1960 the floor area of buildings in the Los Angeles CBD (Central Business District) grew by about 1 million square feet, or 3%; off-street parking, however, grew by 2.5 million square feet, or 203%. No comparable data is available for the UK.

In the US parking is constructed on a regular basis; in most cities new development is contingent on the creation of new parking, and so although all cities have a shortage of streets and freeway space — at least according to traffic management standards — many have a surplus of parking space. Mukhija and Shoup<sup>53</sup> cited evidence that to preserve and enhance walkability, only 9% of a city's land should be devoted to parking, though they claimed there is little empirical basis for this number. Minimum parking requirements are intended to ensure an ample parking supply, and they imply that parking is a problem only when there is not enough of it. The authors argued that regulations on the location of parking should not be implemented uniformly across a city, but should match a larger urban design strategy that recognises the differing characters of neighbourhoods.

Although no one knows the number of parking spaces per car, Victor Gruen (cited by Shoup<sup>54</sup> in a literature review) estimated that for every car in the USA there must be at least one parking space at the place of residence and three to four spaces elsewhere. If this were to be the case in the UK there could be over 85m car parking spaces away from the place of residence since there are 28.4m cars registered<sup>55</sup>. Shoup then supposes that if there are four parking spaces per vehicle and if the average vehicle is worth \$5,352, the average vehicle value per parking space is \$1,338 ( $\$5,352 \div 4$ ). Therefore, according to Shoup, if the average value of a parking space exceeds \$1,338, the average value of four parking spaces exceeds the average \$5,352 value per vehicle they served! Allocating parking spaces by market prices would minimise total walking

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<sup>51</sup> Recommendations for Improving LEED Transportation and Parking Credits, T Litman, Victoria Transport Policy Institute, 2008

<sup>52</sup> Parking, People, and Cities, M Manville and D Shoup, Journal of Urban Planning and Development, 2005

<sup>53</sup> Quantity versus Quality in Off-Street Parking Requirements, V Mukhija and D Shoup, Journal of the American Planning Association, 2006

<sup>54</sup> The Trouble With Minimum Parking Requirements, D Shoup, Transportation Research Part A Vol. 33, 1999

<sup>55</sup> Transport Trends, DfT, 2009

time from parking spaces to final destinations. If minimum parking requirements are eliminated, the ratio of parking spaces to cars would decline, and the price of parking would rise.

In Japan, street parking is forbidden except where parking meters are located<sup>56</sup>. But there are problems. For instance, where street parking for a maximum of five minutes is allowed, many vehicles are observed to exceed the limit; and double parking is common. Furthermore, enforcement has been intermittent and ineffective (although from 2006 local authorities could decriminalise parking enforcement). According to Enoch and Nakamura, the principal cause of urban street congestion in Japan's urban areas is illegal parking, with the primary offender being long-term parking of commercial vehicles. Parking meter charges are typically based on the cost of provision — not on value of spaces to the users, meaning, for example, that charging levels are the same across Tokyo. For off-street spaces in some urban areas, residents require a permit from the police proving they have a parking space before they can purchase a car. However, parking provision is widespread because in city centres many small plots of land are waiting to be developed and so become temporary parking lots (although here users tend to be charged at the market rate). Regarding proposed spaces, the predict-and-provide approach remains very much in force in Japan with national parking regulations requiring urban developers to provide a minimum level of parking spaces if they are to be granted planning permission, which can still be quite high even in central urban areas.

### **Conclusion**

The availability of parking at destinations appears to be an important factor affecting car use and longer-term decisions about land use. There is some evidence suggesting that high levels of provision can lead to an inappropriate use of valuable land and contribute to car dependency.

#### **4.3.2 Parking costs and fees**

### **Research Question 6**

Does the research indicate how drivers respond to the imposition of parking costs and fees?

Parking charges appear to be relatively arbitrary: they do not necessarily reflect the cost of provision, especially of multi-storey car parks; however, nor do they reflect the market price and what users would be prepared to pay. Parking is expensive to provide in new developments, but the basis for these costs is not commonly researched. COST<sup>57</sup> estimated that the cost was about €35,000 a year per space but that this declined with walking distance from commercial centres. In the US however this level is significantly lower than in Europe, presumably because of higher land costs. It was claimed that the capital cost, plus operation and maintenance costs, of parking spaces added by six parking structures built since 1977, was \$124 per space per month (based on the University of California's parking structures built since 1961) and cited by Donald<sup>58</sup>. The DfT estimated that the cost of providing a parking space was £300-500 a year<sup>59</sup>. In the

<sup>56</sup> Transport Policy and Organization in Japan, M Enoch and H Nakamura, *Transport Reviews*, 2, 159 — 180, 2007

<sup>57</sup> *Parking Policies and the Effects on Economy and Mobility*, COST, 2005

<sup>58</sup> *The High Cost of Free Parking*, D Shoup, *Journal of Planning Education and Research*, 1997

<sup>59</sup> *Understanding Successful Workplace Travel Initiatives in the UK*, S Cairns, C Newson and A Davis, *Transportation Research*, 2010 (forthcoming)

USA, minimum parking requirements are set by authorities. These increase the supply and reduce the price – but not the cost – of parking<sup>60</sup>.

Parking is free for many car trips only because its cost has been allocated into higher prices and charges elsewhere. Thus everyone pays for parking whether they use it or not. Cars have many external costs, but the cost of parking in cities may be far greater than all these other external costs combined according to a literature review undertaken by Shoup<sup>61</sup>. Nevertheless while much parking space is provided for free, at the point of use, much is charged for. This may impact upon travel behaviour discouraging some trips or encouraging modal shift.

Recent research undertaken by the DfT<sup>62</sup> asked drivers and passengers to what extent they limited how much they travelled by car because of the cost of petrol, the cost of parking and the availability of parking. The responses to these questions were very similar although the cost of petrol had more effect than the cost and availability of parking. Just over a quarter said they limited their car use a great deal or to some extent because of the cost (27%) or availability of parking (28%), whereas 35% of people said they limited their car a great deal or to some extent because of the cost of petrol. A further 23% said they limited their car use but “not very much”. Once the decision to drive has been taken the cost of parking may be viewed merely as an additional, possibly avoidable, marginal expense.

The EU TransPrice (Trans-Modal Integrated Urban Transport Pricing for Optimum Modal split) project undertook surveys of the public acceptability of transport pricing in six cities – Athens, Madrid, Como, Leeds, York, Graz<sup>63</sup>. After congestion, insufficient parking space was seen as the second (out of six) most important traffic related problem; 78% cited this as a problem but it was much lower in York (44%) and Leeds (45%). Resolutions to the problems saw providing P&R facilities as second (out of six) to improving public transport (91%); reducing parking space was only favoured by 19% and increasing parking costs by 16%. The authors concluded that *“people seem to prefer innovations giving them additional chances or choices. The only restrictive measure which could be designated as accepted by the majority is some kind of access restriction.”*

According to Litman<sup>64</sup> charging users directly for parking tends to be more efficient and equitable, and generates revenues that can finance new services or reduce taxes. He supports his case by a mixture of qualitative and quantitative research with some case studies supplementing his personal opinions as an economist. He claims that the potential benefits include:

- Increased turnover of the most convenient spaces. This increases consumer convenience, facilitates deliveries, and reduces cruising for parking (searching for an unoccupied space).
- Reducing the number of spaces needed to meet demand, reducing total parking costs, and allowing more compact development.
- Encouraging long-stay parkers to use less convenient spaces (such as off-street or urban fringe), and encourages travellers (particularly commuters) to use alternative modes when possible.
- Reducing total vehicle traffic and therefore problems such as traffic congestion, accidents, energy consumption and pollution emissions.
- Generating revenue; ensuring that users pay a greater share of municipal road and parking costs.

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<sup>60</sup> The Trouble With Minimum Parking Requirements, D Shoup, Transportation Research Part A, 1999

<sup>61</sup> The Trouble With Minimum Parking Requirements, D Shoup, Transportation Research Part A Vol. 33, 1999

<sup>62</sup> Public Experiences of and Attitudes Towards Parking, DfT, 2009

<sup>63</sup> Public Acceptability of Traffic Demand Management in Europe, B Schlag and J Schade, Traffic Engineering & Control, 2000

<sup>64</sup> Parking Pricing Implementation Guidelines, T Litman, Victoria Transport Policy Institute, 2010

Parking pricing could cause various transportation system changes<sup>65</sup>:

- Reduced vehicle ownership (particularly pricing of residential parking);
- Mode shifts (from driving to walking, cycling, and public transport);
- Destination shifts (to areas with cheaper parking); parking location changes (to cheaper or free parking spaces);
- Trip schedule changes (from priced to unpriced periods); and
- Shorter stop duration.

Demographic, geographic and economic factors affect these changes: larger impacts are likely to result with lower-income motorists, more discretionary trips, and if travellers have better alternative modes, destinations and parking options.

However it is difficult to use parking revenues to pay for the entire cost of off-street parking facilities, according to the Metropolitan Transportation Commission in California<sup>66</sup>. In most cases, the high development costs, and limited funding opportunities, results in the need to identify alternative funding and financing options.

The cost of providing car parking is not trivial according to the literature review by Shoup<sup>67</sup>. In the US aboveground structured parking often costs about \$10,000 per space and underground parking often costs about \$25,000 per space. Larger developments require more parking spaces which add to the overall cost of the building; the most common parking requirement for an office building is four spaces per 1,000 square feet of floor area.

Shoup argued that market prices would allocate parking spaces among motorists in a logical way. The more convenient parking spaces would go to carsharers, those in a hurry, those who want to park for only a short time, those who have difficulty walking, and those more willing to spend money. The best parking spaces could always be reserved for those with physical disabilities. The more distant parking spaces would go to SOV drivers, those with time to spare, those who want to park a long time, those who enjoy walking, and those more eager to save money. If minimum parking requirements were eliminated, the ratio of parking spaces to cars would decline, and the price of parking would rise.

This price rise would have two effects on the demand and supply of commercial according to Shoup:

- First, motorists would economise on parking by changing their travel behaviour. Shifting to higher occupancy vehicles to spread the cost of parking among more people would reduce the demand for parking; shifting to walking, cycling, or public transport will also reduce the demand for parking; shifting vehicle trips to off-peak (so reducing the demand for parking at peak hours if off-peak charges were lower) and finally, citizens may choose to own fewer cars, and this would also reduce the demand for parking.
- Second, freed from minimum parking requirements, developers of commercial property would supply parking spaces in response to parking prices. The higher price of parking would encourage developers to voluntarily supply more parking in places where the resulting revenue would cover the cost of providing the parking. Parking would tend to become unbundled from other transactions, and firms that specialise in providing parking would manage more of the parking supply. Off-street parking prices would tend to cover the cost of providing parking spaces, including the cost of land, and these off-street prices would put a ceiling

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<sup>65</sup> Parking Pricing Implementation Guidelines, T Litman, Victoria Transport Policy Institute, 2010

<sup>66</sup> Developing Parking Policies to Support Smart Growth in Local Jurisdictions, Metropolitan Transportation Commission in California, 2007

<sup>67</sup> The Trouble With Minimum Parking Requirements, D Shoup, Transportation Research Part A Vol. 33, 1999

on the price of adjacent curb parking. Market prices for parking resemble a spot market for land. Demand-responsive parking prices would reveal what parking spaces are really worth, and how motorists would be willing to change their travel choices to save money on parking. Motorists could choose parking spaces according to how long they want to stay, how many people are in the car, how they value walking time (are they in a hurry? are they carrying heavy packages? are they tired? are they short of money?) and many other circumstances of time and place that only the individual motorists can know.

The effects on supply and demand from price increases assume that frequent and high quality public transport provision exists which may not be the case in rural areas where alternative mobility options are limited. However, parking charges can have a positive impact on public transport use<sup>68</sup>. Although it is suggested that it may not be as effective as other interventions such as company car taxation changes, fuel taxes, congestion charges, fare structure changes or fare levels.

Market prices would not allocate the best parking spaces only to the rich but others would not be able to regularly afford to park in the best parking locations<sup>69</sup>. With market prices, motorists can pay less for parking if they carpool, stay for a shorter time, or park farther away, and they would pay nothing for parking if they walk, bicycle or use public transport. Even those who cannot regularly afford to park in the best spaces could park occasions when time is very valuable. But because income is only one factor that determines the value of time on a particular trip, and because the value of time is only one factor that determines parking location, income is only one of many factors that determine parking location. Shoup therefore proposes a system of demand-responsive parking charges.

When motorists pay directly for parking, it is often a flat fee, providing little incentive to use an alternative mode occasionally. Rates should be set to optimize parking facility use, called *performance-based pricing*, which means that about 15% of parking spaces are vacant and available at any time<sup>70</sup>.

Table 2 below contrasts the results of 22 international TDM programmes which incorporated parking pricing strategies and parking supply strategies<sup>71</sup>. Parking restraint policies can be broadly grouped into those which aim to reduce car travel through parking pricing mechanisms, and those which aim to control parking supply (of course, combinations of the two are also common but no data was presented of the number of combined). More examples of parking restrictions than parking pricing were found and these tended to generate greater trip reductions.

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<sup>68</sup> The Demand for Public Transport, R Balcombe (Editor), TRL, 2004

<sup>69</sup> The Trouble With Minimum Parking Requirements, D Shoup, Transportation Research Part A Vol. 33, 1999

<sup>70</sup> Cruising for Parking, D Shoup, Transport Policy 13 479-486, 2006

<sup>71</sup> International Approaches to Tackling Transport Congestion, Booz Allen Hamilton, 2006

**Table 2: Relative Effect of Parking Pricing and Supply in TDM Programmes**

	Parking Charges	
Program Net Trip Reduction	No	Yes
> 30 %	1	5
15 - 30 %	2	7
< 15 %	5	2
	Restricted Parking	
Program Net Trip Reduction	No	Yes
> 30 %	1	5
15 - 30 %	0	9
< 15 %	4	3

Rietveld<sup>72</sup> argued that the externalities of transport are not only derived through the number of kilometres driven but also by road type, time of day, type of vehicle and driving behaviour. In *Pricing Mobility: Experiences in the Netherlands*, he reported that 55% of car related taxes are linked to car ownership and that 45% are attributed to car use. During the last 20 years the Netherlands has endeavoured to harmonise the tax system to take account of the differentiation between the two taxes to ensure that external costs are internalised. Rietveld suggested that parking fees are a second best solution to congestion charging for the following reasons:

- Parking fees only apply to public parking space:
- Parking fees do not take account of the origin of the trip and therefore distance travelled; and
- Parking fees are dependent upon the length of the parking period.

In addition, the experiences reported within the Netherlands recognised the complexity of parking pricing and the collection of taxes which can vary between municipality, particularly within cities, which comprises business and residential functions. These findings mirror the findings of the previous section where Mukhija & Shoup suggested parking regulations are tailored to the characteristics of the locality.

Thorpea, Hillsa and Jaensirisak<sup>73</sup> reviewed the results of a range of data analyses of users' attitudinal responses to various travel-demand management measures in two case-study cities in the UK; Newcastle and Cambridge. Attitude surveys were administered in each city which, followed by a city-specific survey, was designed to investigate specific issues in more detail. Face-to-face interviews and postal surveys were also undertaken. The analyses confirmed the high level of inherent public acceptance for improving public transport relative to restraint-based measures such as road-user charging, increased parking charges and zone-access control. Furthermore, most respondents stated that road-user charging was the most acceptable and increased parking charges the least acceptable pricing intervention. In contrast, a sample population of 240 university campus employees in Israel were provided with two scenarios, a congestion toll or parking fee, and reported that the readiness to pay parking fees was greater<sup>74</sup>. This study used a stated preference survey and also

<sup>72</sup> Pricing Mobility: Experiences in the Netherlands, P Rietveld, Transportation Research, 2001

<sup>73</sup> Public attitudes to TDM measures: a comparative study, N Thorpea, P Hillsa and S Jaensirisak, Transport Policy 7, 2000

<sup>74</sup> Congestion Tolls and Parking Fees: a Comparison of the Potential Effect on Travel Behaviour, G Albert and D Mahalel, Transport Policy, 2006

highlights the fact that within Israel, congestion pricing had not yet been introduced, therefore the findings should be treated with caution.

A 'suboptimal flat surface parking tax' is put forward in a paper on *The Case for Taxing Surface Parking* with a view to capturing multiple externalities and as an alternative to minimum or maximum parking standards<sup>75</sup>. Fietelson and Rotem reviewed literature on parking requirements and concluded that this subject has received little attention and, where research exists, the focus has been on the short term effects of parking constraints or fees. Surface parking generates multiple externalities. If left to the market the supply of parking is likely to be suboptimal. But parking requirements ignore most of the externalities. This paper suggested that a tax approach may be a more efficient method to internalise the externalities associated with parking provision, thereby assuring an optimal supply of parking.

Barter<sup>76</sup> advocated the use of market based parking policy and how to achieve it. He categorised parking policy through three approaches (see table 3 below):

**Table 3: Barter's Approaches to Parking Policy**

**Table 1. The three approaches to parking policy**

	Conventional	Parking management	Market-based parking
Perspective on parking problem	Scarcity is a problem, both within a vicinity or on any site, because it causes spillover and conflict.	Problem if parking conditions mismatch with wider policy goals. Trade-offs among objectives are difficult.	Underpriced on-street parking causes search externality and inhibits off-street market. Supply-side policy causes more problems than it solves.
View of spillover	Seen as a free-rider problem. To be avoided by ensuring each site handles its own parking.	A source of conflict, so minimise by management or defuse by planning for shared parking.	Pricing defuses spillover problem. It is welcome as a trigger for market pricing to emerge.
How quantity of parking should be determined	Require developers to supply enough to meet all expected demand on-site (often at a price of zero).	Plan and manage, using diverse policy tools, for parking quantity, location and usage patterns to match wider policy goals.	Facilitate efficient on-street pricing. Remove obstacles to private choices determining supply in local off-street markets.
Perspective on shared parking (open to public)	Unusual since each site expected to provide for own parking.	A useful tool but needs careful management to avoid conflict.	Expected to be the norm. Restricted-access parking as exception not norm.

Barter describes the Conventional approach as one where parking has been bundled in with other services such as housing or employment and where on-street parking that is insufficient and is boosted by off-street parking. The disadvantages of this approach include an increase in development costs, the promotion of low density development and urban sprawl, and a lack of travel choice. Barter suggests that this approach is unsuitable for congested areas and asserts that pricing measures have been adopted in many cities particularly where a parking problem exists. However it is not widely used in suburban areas where the conventional approach still dominates.

<sup>75</sup> The Case for Taxing Surface Parking, E Fietelson and O Rotem, Transportation Research D 9, pp 319–333, 2004

<sup>76</sup> Off-Street Parking Policy without Parking Requirements: A Need for Market Fostering and Regulation, P Barter, unpublished, 2010



In the Parking Management approach supply remains under planning control to ensure sufficient parking. In contrast, in the Market Based approach, deregulation of the quantity of off-street parking is the main focus with a view to enabling operators to manage their parking supply and business considerations (not through zoning). In this approach parking is market based and parking standards would cease to be used although some initial policy effort would be required to achieve it. The essence of this approach is that the prices do the planning for parking.

Market based policies may be considered by some people to be inequitable i.e. any welfare gains are not captured by those who would value them highly but who do not have the purchasing power. Equity can be evaluated in many different ways however, reflecting different concerns and perspectives<sup>77</sup>. From an equity perspective a parking tax could be considered as most equitable if it is broadly applied. From this perspective a per-space tax and more public parking pricing appear most equitable. Parking taxes and fees can be considered user fees, which are therefore most equitable if they reflect the external costs of parking facilities and motor vehicle use. From this perspective per-space taxes and pricing public parking appear most equitable, especially if such taxes and fees vary to reflect differences in costs, such as higher rates in denser urban areas.

### **Conclusion**

Much research has demonstrated the importance of parking costs to travel choices although the extent of the impact may vary. A combination of parking charges and reducing or restricting parking availability is likely to be most effective in encouraging behavioural change.

### **4.3.3 Elasticities and pricing**

#### **Research Question 7**

Is there agreement across research studies of an estimated price elasticity for parking both in the short and long run?

Various studies have estimated price elasticities of parking. More than 50 studies were reviewed by de Jong and Gunn<sup>78</sup> who also conducted three model runs using the TRACE model. They pointed out that elasticities of travel demand vary with circumstances and concluded that most evidence relates to mode choice. A 10% change in car journey time has a bigger impact on the number of trips made and kilometres travelled than a 10% change in car use costs.

High levels of demand elasticity were noted in *Congestion Tolls and Parking Fees: A Comparison of the Potential Effect on Travel Behaviour*<sup>79</sup>: -1.8 for congestion tolls in the USA and -1.2 for parking fees. These figures demonstrated that the effectiveness of congestion tolls in reducing demand is higher during the times the tolls apply than parking charges.

Evans<sup>80</sup> calculated central elasticity estimates of the change in mode, destination and trip frequency among chargeable car trips; in response to the change in money costs (fuel cost and the charge) of the central congestion charge zone (CCZ) and the proposed western extension (WEZ). Using the SPAM2 model these were calculated as: -0.47 in

<sup>77</sup> Equity Evaluation, T Litman, Victoria Transport Policy Institute, 2005

<sup>78</sup> Recent Evidence on Car Cost and Time Elasticities of Travel Demand in Europe, G de Jong and H Gunn, Journal of Transport Economics and Policy, 2001

<sup>79</sup> Congestion Tolls and Parking Fees: A Comparison of the Potential Effect on Travel Behaviour, A Gila and M David, Transport Policy, 2006

<sup>80</sup> Demand Elasticities for Car Trips to Central London as Revealed by the Central London Congestion Charge, R Evans, TfL study, 2008

the CCZ and -0.42 in the WEZ; elasticity ranges of -0.40 to -0.51 for the CCZ and -0.36 to -0.46 for the WEZ were claimed. In the CCZ, if values of time are included along with fuel and congestion charge costs in a measure of generalised costs, the elasticity with respect to generalised costs was in excess of -2.0.

In a, now fairly old, stated preference study<sup>81</sup> of 220 respondents, a comparison of values of time was reported (see table below). The study applied five ranges for parking costs to ascertain responses to hypothetical situations (see table 4 below).

**Table 4: Values of Parking Time and Costs Applied**

Travel feature	Value
Search time (cost/min)	7.6pence per min
Cost of parking (£)	Free; £0.00-£1.50; £1.51-£3.00; £3.01-£5.00; > £5.00
Value of walk time (p per min)	7.0p min (Drive time = 3.6pence per min)

The values for travel times varied depending upon the type of journey undertaken (see table 5 below).

**Table 5: Detailed Comparison of values of Time (pence per minute)**

	Search Time	Walk Time	Drive Time
<b>Home to Work</b>	7.8	7.0	4.2
<b>Home to Shopping</b>	7.3	7.4	3.4
<b>Other home based</b>	7.3	6.1	3.2
<b>Non-home based trips</b>	8.1	7.6	3.7

As drivers' incomes rise the monetary values for all three parking factors (searching, walking and driving time) rises as well (see Table 6 below).

**Table 6: Response to Reduced Availability of Parking (%)**

	Continue to park	Trip suppression
<b>Home to work</b>	44	
<b>Home to shops</b>	20	36
<b>Home to other</b>	23	32
<b>Non-home trips</b>	19	31

People often continue to drive and to park especially travelling to work while non-work trips appear to be suppressed. The proximity of parking spaces to the final destination is also a key determinant of car use, particularly for journeys to work or to the shops (see table 7 below).

<sup>81</sup> Study of Parking and Traffic Demand: Stage 2 – Report of Stated Preference Research, MVA for DfT, 1996

**Table 7: Reasons for Travelling by Car (%)**

	Work	Shopping	Other
<b>Closeness</b>	60	60	48
<b>Cost</b>	20	15	21
<b>Choice of space</b>	5	15	26
<b>Other</b>	15	10	5

Best estimates of parking demand elasticities for CBD areas (derived from a number of Booz Allen studies and reviews, as well as consultations, and reported in *International Approaches to Tackling Transport Congestion*<sup>82</sup>) were as follows:

0-2 hours: -0.1  
 2-4 hours: -0.3  
 4-7 hours: -0.5  
 7+ hours: -0.9

Thus, a 10% increase in parking charges would result in a 1% decrease in parking demand for people who park for up to 2 hours, a 3% reduction in demand for people who park 2-4 hours etc. This might imply that people respond more to the absolute cost of parking rather than the percentage increase. Alternatively it may be that most people only wish to park for a relatively short period, perhaps for shopping.

A parking survey using a simple questionnaire card was undertaken in Croydon in order to produce, inter alia, information about behaviour patterns of parkers and so extend the usefulness of ticket sales data available for the period 1972-78<sup>83</sup>. Data on car park occupancy showed that employees represented 44% of parkers but used 65% spaces; shoppers represented 49% of parkers but only used 28% of spaces due to higher turnover and shorter stays. On average P&R users required 30% of spaces in a commuter car park. Vehicle occupancy varied with 72% of employee drivers using a SOV, 64% of shopping drivers were partnered by at least one passenger. The average duration of stay was 6.9 hours for work trips and 2.9 hours for shoppers. The authors concluded that the study has shown that a detailed understanding of the characteristics of a towns parking system can be achieved at relatively low cost and effort.

According to the RAC<sup>84</sup> stated preference study if the cost of parking at work reached what they considered to be very high levels 16% of respondents said that they would walk or cycle and 31% would use public transport; but almost a quarter of people said they would consider changing jobs if parking costs became too high. Only 6% of people would still pay to park at work.

The car parking policies of Manchester City Council in establishing scales of parking charges were described and evaluated by Haworth and Hilton<sup>85</sup>. Scales of charges were introduced in the city to increase revenue and to reduce the deficit attributable to six car parks. The aim of the policy was to maximise usage of all available central-area parking spaces. An analysis of the patronage of 1-2 hour parking users showed how the responses directly followed the individual charges i.e. a reduction in use following price rises (possibly with a gradual increase in use over time). This study was used to show the

<sup>82</sup> International Approaches to Tackling Transport Congestion, Booz Allen Hamilton, 2006

<sup>83</sup> A Question of Parking, H Pearce and P Jackson, Traffic Engineering & Control, 1979

<sup>84</sup> Parking in Transport Policy, RAC, 2005

<sup>85</sup> Parking Elasticity - a Tool for Policy Implementation, SL Haworth and IC Hilton, Traffic Engineering & Control, 1982

detailed control possible of users' responses through price regulation for a specific length of stay at a particular car park.

Can the UK learn from the experience of north America? Guidance on parking pricing implementation<sup>86</sup> described the benefits and costs of pricing of parking, ways to overcome common obstacles and objections, and examples of successful parking pricing programmes. He reported that the price elasticity of vehicle trips in the US with respect to parking price is typically  $-0.1$  to  $-0.3$  (a 10% increase in parking fees reduces vehicle trips by 1-3%), depending on conditions. In the short run, cost-recovery parking pricing (fees set to recover the full costs of a parking facility) typically reduced the number of spaces needed to serve a destination by 10-30%.

Many studies (including those cited by Litman<sup>87</sup>) have estimated the elasticity of parking demand. In an evaluation of various types of parking taxes and their impacts with regard to various planning objectives, he reported that elasticities typically range between  $-0.2$  and  $-0.4$ , indicating that a 10% increase in parking price reduces parking demand by 2-4%. Many factors can affect these impacts. Price elasticities tend to be greater for long-stay parking such as by commuters than for short-stay parking such as by shoppers, and are greater for a particular location (for example, a particular car park) than an area (for example, if all car parks in a town centre increase their prices), since some motorists respond to price differences by changing where they park. These elasticities indicated that a 20% commercial parking tax which is fully passed on to users would, according to Litman, reduce parking demand in areas dominated by commercial parking by 4-8%, but reduce only a much smaller portion of total travel.

Several studies have analysed parking elasticities in European countries.

Based on a sample survey involving 710 interviews in Gran Canaria, Spain, Espino *et al*<sup>88</sup>, an analysis of suburban travel demand was undertaken. A Revealed Preference survey was used to adapt the choice experiment to each respondent's expectations. A Stated Preference Survey, which generated 871 observations, was also used. Choice experiments between car and bus use, which allowed for interactions among the main policy variables: travel cost, travel time and frequency, were applied. Different model specifications were tested accounting for the presence of income effects, systematic taste variation, and incorporating the effect of latent variables. Stated Preference was applied using focus groups associated with nested logit specifications (a discrete choice approach) using revealed/ stated preference data. An increase of 50% in parking charges was tested along with lower bus fares, increased bus frequencies (50% and 100% increases) and reduced bus travel time (a 10% reduction). The study reported that parking cost cross-elasticities are quite small; the reason is that there are a significant number of individuals that do not pay for parking and for them the effect of this variable in the elasticity computation is zero. However, policies involving increments in parking costs produce the highest demand response when all individuals pay for parking. Demand is more sensitive to policies that penalise private car use than improving public transport. The analysis showed that the subjective value of time decreases as comfort is improved. The quality of public transport is clearly important in determining travel behaviour, in addition to parking costs.

Walking distances are important; in Finland car drivers would pay €0.65 extra to park 100m closer to their destination; other studies report lower amounts: €0.45-€0.5 (cited by COST<sup>89</sup>). The Finnish survey indicated that an increase in parking costs of 30% resulted in an increase in car share of 8-10%, more so for commuter traffic. A doubling of parking costs would lead to a decrease in car use of 21% but if public transport fares were 30% cheaper car use would only fall by 2%. However, increasing walking

<sup>86</sup> Parking Pricing Implementation Guidelines, T Litman, Victoria Transport Policy Institute, 2010

<sup>87</sup> Parking Taxes: Evaluating Options and Impacts, T Litman, Victoria Transport Policy Institute, 2010

<sup>88</sup> Understanding Suburban Travel Demand: Flexible Modelling with Revealed and Stated Choice Data, R Espino, J de Dios Ortúzar, C R Espino, Transportation Research Part A 41, 2007

<sup>89</sup> Parking Policies and the Effects on Economy and Mobility, COST, 2005

distances to destinations from parking to a minimum of 400m would reduce car use by 9%. Reducing public transport travel times by 15% would reduce car use by only 2%.

In a Belgian study, Proost and Van Dender<sup>90</sup> applied a two-period (peak and off-peak) multimodal model of the urban transport system. The model (a nested CES utility structure) contained about twenty transport markets, which varied in terms of resource costs, external costs, taxes, and demand characteristics. Comparing Brussels and London the study noted that free parking is available for an estimated 70% of car users in both case studies. Parking costs per km were much higher in London than in Brussels, reflecting higher opportunity costs of land. Optimal prices were higher than current prices in most transport markets, so that optimal demand was below actual demand. There is a strong shift to public transport in the peak period. Second-best policies may be feasible options e.g. less access to free parking. Removing existing subsidies to public transport, and to parking, internalising transport externalities (mainly congestion) and optimising the frequency of transit service increased welfare by approximately 2%. This study showed that introducing resource cost pricing - the cost of a resource during a specific time period - of all parking spaces (instead of providing 70% of them for free) generated approximately 30% of the welfare gain – the transfer of benefits from the better to the less well-off - of fully optimal pricing.

In a specialist study of skiers in Sweden, COST<sup>91</sup> found that the introduction of a Sfr40 fee caused the majority of drivers to switch to another resort with free parking; 24% would stay at home and 29% would use public transport. A unilateral increase in parking charges may therefore be counter-productive.

In *A Review of the Impact of Parking Policy Measures on Travel Demand*<sup>92</sup> 19 studies were considered. This review of Disaggregate Modal Choice Models, Discrete Parking Location Models and site-specific studies of parking behaviour concluded that there was a great variation in parking elasticities quoted in site-specific studies. Few modal choice models deal adequately with parking. Some support was found for the view that parking policy is an important factor for modal choice.

Averaging parking charges among those who do and do not pay them is not entirely satisfactory, but is, nevertheless, a common approach. For those who do not pay, the elasticities which omit parking charges are probably reasonable estimates. For those who do pay to park, the averaged parking charge is too low, but evidence on the different demand responses among those who do and do not pay to park is unclear.

Significant variation has been found in the price elasticities quoted; this is consistent with the findings of previous reviews. The mix of free and priced parking will confuse the results and other factors that influence car-use e.g. walking distances, public transport provision, parking charge levels, real incomes etc will all have an effect.

### **Conclusion**

Research on pricing mechanisms asserts that the parking fees do not reflect the full externalities of car usage. Elasticity ranges vary greatly – time, location etc - and therefore must be interpreted within the context they are reported. However they do provide an insight into the social and political acceptability of a range of parking policy measures. Information on long-run elasticities is lacking as few time-series analyses have been undertaken; this is important since parking charges probably lag behind rises in income. Further research is needed into the cross-price elasticities of parking demand with respect to public transport improvements.

<sup>90</sup> Optimal Urban Transport Pricing in the Presence of Congestion, Economies of Density and Costly Public Funds, S Proost and K Van Dender, Transportation Research Part A 42, 2008

<sup>91</sup> Parking Policies and the Effects on Economy and Mobility, COST, 2005

<sup>92</sup> A Review of the Impact of Parking Policy Measures on Travel Demand, B F Feeney, Transport Planning and Technology, 1989



**Quick wins**

An investigation of the responsiveness of parking demand using time series analysis could be undertaken. Further research should be undertaken into the responsiveness of parking demand to public transport fares and service levels as well as incomes. An econometric study could investigate the impact of parking behaviour in response to income and parking charge changes over time.

Given the range of figures cited by the various studies quoted a meta-analysis of the available research that have calculated price elasticities could be undertaken to generate a better estimate of the values in the UK.

**4.3.4 Town centres****Research Question 8**

Does research demonstrate that the time taken to park is a key determinant of parking behaviour?

Searching for a parking space in town centres can cause stress when travelling by car<sup>93</sup>. Examples were given by Hilton to show how simple, existing parking information systems fail at peak parking times and that most signals give no help when all the car parks are full. A technique to predict parking access time (the interval from a driver receiving the information to the car passing the entry point of the parking place) and road signs for its display in terms of parking time were described. The potential for in-car route guidance systems to offer drivers a choice of public parking space was examined. Prediction of access times depended upon a number of factors: whether or not the car will join the queue for entry; its travel time in the prevailing traffic conditions; its rank for admission; future departures from the car park and the dynamic admission capacity of the car park. Better parking information improves efficiency.

Tsopelas, Ling and McCarthy<sup>94</sup> reflected these conclusions. They undertook before and after interviews: the first survey was of 873 drivers; the second of 101 (who had agreed to participate in the first survey); and the third of 889. The second survey was seven months after the initial operation and the third was one year after implementation. Parking guidance and information systems, such as the web-based system described in their paper, have been developed to reduce the time spent in the search of parking space and to increase the overall efficiency of the traffic network. This before and after study showed that the final destination was critical in the choice of a car park despite improvements in information provision.

Shoup<sup>95</sup> reviewed studies of cruising for parking in congested downtown areas in Los Angeles in a paper titled 'Cruising for Parking'. He developed a model which considers how drivers choose to cruise or pay for a parking space. His research concluded that people are more likely to cruise for a parking space if it is cheap, off street parking is expensive, parking is required for a long time, the person is alone in the car and places a low value on time.

<sup>93</sup> Parking Access Time: the Pertinent Information for Users of Public Parking Facilities, IC Hilton, Traffic Engineering & Control, 1989

<sup>94</sup> Creating a Car park Search Engine for Manchester's Drivers, I Tsopelas, D Ling and T McCarthy, Traffic Engineering & Control, 2002

<sup>95</sup> Cruising for Parking, D Shoup, Transport Policy, Traffic Engineering & Control, 2006

Vehicle parking manoeuvres on busy roads serving retail and commercial activities were analysed using video recordings in two streets in Manchester<sup>96</sup>. Three types of on-street parking were observed:

- Parallel on-street parking (legal);
- On-street parking (illegal); and
- Angle on-street parking (legal).

Parking manoeuvre times were calculated as the length of time required by vehicles to enter or leave the space. The results (in table 8 below) indicated that parking manoeuvres which involved reversing to park or leave required, on average, a relatively longer time to complete. Angled parking always requires a reversing manoeuvre.

**Table 8: Parking time (seconds)**

	<b>Entering</b>	<b>Leaving</b>
Parallel on-street parking (legal)	11.7	5.6
On-street parking (illegal)	4.9	5.1
Angle on-street parking (legal).	4.9	9.9

Unsurprisingly parking manoeuvres that involve reversing take longer than others and may cause temporary bottlenecks to traffic. Interestingly illegal on-street parking is quickest.

Parking is often viewed within the context set by wider transport policy initiatives for town centres. For example, a study in York<sup>97</sup> was undertaken to:

- a) help determine the future pattern of development in York;
- b) collect and analyse current traffic demand data;
- c) provide tools to facilitate the assessment of alternative policies and actions;
- d) forecast future travel demands and test a range of highways and parking options; and
- e) prepare policies for implementation in the year 2006, with a short to medium term focus.

An extensive programme of traffic and parking surveys was undertaken in 1987 in York. Data collected included registration numbers, junction counts, automatic traffic counts and journey time surveys. Interview surveys were conducted at public car parks. Using a Saturn model (involving a parking location model and a parking tariff model) a package of procedures and policies – an urban strategy - to address parking/P&R issues was generated based on the analysis undertaken.

Golias, Yannis and Harvatis<sup>98</sup> dealt with the determinants of choice between on- and off-street parking. In this context, a questionnaire-based survey was conducted in Pireaus, Greece, and a stated preference method used to develop an explanatory model. A random sample of 317 respondents generated data comprising values of parameters assumed to have an impact on the choice of parking alternatives and an indicator of the choice made by the interviewee. The model assessment showed that parking cost has the most important impact on the choice of parking alternatives. Furthermore, all other variables with a significant impact on parking choice are time related, i.e. search time for a parking space, duration of parking and walking time from the parking space to the final

<sup>96</sup> On-Street parking: Effects on Traffic Congestion, S Yousif and Purnawan, 1999

<sup>97</sup> A Comprehensive Approach to Traffic and Transport Policy: a case-study of York, D Jones, S Rutherford and J Rigby, Traffic Engineering & Control, 1989

<sup>98</sup> Off-Street Parking Choice Sensitivity, J Golias, G Yannis and M Harvatis, Transportation Planning and Technology, 2001



destination. Thus, time and cost seem to be dominant factors in the case of parking choices, as they may be in all transport related choices. Parking choice decisions do not depend on driver and trip characteristics. The authors concluded that the improvement of parking conditions had a direct impact not only on the improvement of traffic conditions and road safety in the area considered, but also on the local economy.

A detailed investigation of the inter-relationship between on-street parking and choice of mode for journeys to work in Edinburgh<sup>99</sup> was undertaken by Rye, Cowan and Ison. This city is typical of many in that its centre has significant on-street parking controls but, beyond a radius of 1 to 1 1/2 miles (1.5 to 2.5 km) there are no controls and commuter parking on-street is commonplace. Some 750 questionnaires were distributed and 466 returned, a response rate of 62%. Many respondents were given a free PNR space: 41% of the private car users and 15.5% of total commuters. Extrapolating the survey findings city-wide implied that over 11,000 people were parking in free on-street spaces and then walking or taking the bus to their final destination. It is no surprise, therefore, that there was considerable parking stress in areas surrounding the city centre.

Of the PNR parkers, 64% (46 in number) answered the question of how they would travel/ where they would park if they did not have a PNR space available: 28 stated that with a half-mile extension (0.8 km), they would continue to drive but park outside the zone, walking from there to work. However, with a 1.5 mile extension (2.5 km) only 8 people would do this, with the majority claiming that they would change mode, predominantly to the bus. Of the 49 commuters who currently park in an on-street space just outside the existing CPZ the majority were able to park relatively close to their workplace.

Successively greater (hypothetical) increases in the CPZ extent caused more people to say that they would change their parking behaviour: extensions of 1/2, 1 and 1 1/2 miles (0.6, 1.5 and 2.5 km) were seen to reduce those driving and seeking a free on-street space by 26.5%, 69.4% and 75.5%. Comparing the results for the current boundary and its expansion by 1 1/2 miles (2.5 km) showed a reduction in the number of people commuting by private car by 21%. The resultant modal shift amongst the 466 commuters surveyed was a 1.5% increase in walking, 3.2% increase in bus use and 0.4% increase in train use. This is shown in the Table 9 below.

The location of the workplace in relation to the edge of the boundary was a significant factor in the number using a free on-street space since 2/3 were employed in the periphery of the Edinburgh CPZ. Thus an expansion of the CPZ may result in these drivers changing to another mode, rather than combining a car journey (and parking further from their work) with another mode such as public transport, walking or cycling.

**Table 9: Mode shift resulting from expansion in CPZ area (all travellers)**

Mode	Current CPZ	½ mile expansion		1 mile expansion		1½ mile expansion	
		Modal share	Change (% point)	Modal share	Change (% point)	Modal share	Change (% point)
Car	37.9	35.1	2.8	30.6	7.3	30.0	7.9
Walk	16.1	17.4	1.3	17.9	1.8	18.4	2.3
Bus	37.9	39.2	1.3	42.8	4.9	42.9	5.0
Train	4.7	4.9	0.2	5.3	0.6	5.3	0.6
Cycle	3.4	3.4	0.0	3.4	0.0	3.4	0.0

<sup>99</sup> Expansion of a Controlled Parking Zone (CPZ) and its Influence on Modal Split: The Case of Edinburgh, T Rye, T Cowan and S Ison, Transportation Planning and Technology, 2006

The authors<sup>100</sup> concluded that on-street parking controls could, if combined with restrictive off-street provision (and improved public transport), reduce the number of commuter trips by private car. Furthermore the results could be transferable elsewhere but that the scale of the impacts would be related to site-specific factors, particularly the demand for on-street residential parking space.

Once a CPZ system is introduced there are also other difficulties to consider in addition to parking on the periphery of the zone. A problem experienced in many town centres is illegal parking. This can create danger as well as possibly reducing the capacity of the highway network. Few studies have been undertaken of the effect. In one set of interviews<sup>101</sup> however respondents did not perceive the community impact of illegal parking as a serious issue but saw a reward in terms of convenience for car users. They had little respect for traffic wardens who are not perceived as helping the public. Respondents also had a lack of regard for decisions of the local authority over parking. Penalties for illegal parking were thought to be open to contest since the rules are considered to be unclear and variable.

Parking violation and enforcement is seldom mentioned in the literature<sup>102</sup>. However, the level of parking offences has been found<sup>103</sup> to be significantly high and therefore it is important to investigate the offender's behaviour and the policies designed to deter parking offences as well as the cost of enforcing parking.

Parking restrictions confuse millions of motorists and over a third of drivers who receive a ticket do not accept they have parked illegally, according to a study<sup>104</sup>. The DfT found that almost a fifth of respondents to a recent survey thought that parking restrictions were not clear. Eighteen percent of car drivers interviewed had received a parking ticket in the last year, of whom 37% thought the penalty was unjustified.

Petiot<sup>105</sup> argued that it is difficult to ascertain the impact of increases in parking fines on travel demand and that it is not clear whether this increase will reduce car use when drivers do not pay for their parking. Based on a parking behaviour model<sup>106</sup> which links fine level choice, non-compliance behaviour, modal split and travel demand, Petiot concluded that the fine increase actually increases car use and encourages parking violation. This conclusion contradicts some of the research previously done which accepts the fact that an increase in the enforcement effort deters parking offences<sup>107</sup>. Therefore, Petiot recommended that the model should include other, more empirical factors such as road congestion to confirm these theoretical results.

A study in the Netherlands<sup>108</sup> considers the attitudes of drivers towards planned parking measures at a university campus in Eindhoven, using an on-street questionnaire and multinomial logit analysis (where data are assumed to be case specific; that is, each independent variable has a single value for each case). When asked about restrictions to parking within the campus, almost half of the drivers indicated that they would alter their travel behaviour either by changing mode or parking outside the campus area should they be required to pay for parking. In addition the Netherlands has introduced the ABC approach to parking standards which is useful with regard to town centre parking standards:

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<sup>100</sup> Expansion of a Controlled Parking Zone (CPZ) and its Influence on Modal Split: The Case of Edinburgh, T Rye, T Cowan and S Ison, Transportation Planning and Technology, 2006

<sup>101</sup> Respect on the Road, T Porter and B Toombs, Cragg Ross Dawson for DfT, 2006

<sup>102</sup> Parking Enforcement and Travel Demand Management, R Petiot, Transport Policy 11, 2004

<sup>103</sup> Illegal Parking and the Enforcement of Parking Regulations: Causes, Effects and Interactions, K Cullinane and J Polak, Transport Reviews, 121992

<sup>104</sup> Public Experiences of and Attitudes Towards Parking, DfT, 2009

<sup>105</sup> Parking Enforcement and Travel Demand Management, R Petiot, Transport Policy 11, 2004

<sup>106</sup> Modelling Parking, R Arnott and J Rowse, Journal of Urban Economics, 1999

<sup>107</sup> On-street Parking Meter Behaviour, A Adiv and W Wang, Center for Transit Research and Management Development University of Michigan Transportation Research Institute, 1987

<sup>108</sup> Attitudes and Behavioural Responses to Parking Measures, P Van der Waerden, A Borgers and H Timmermans, EJTR, 2006

- A. Highly accessible by public transport but with restrictions on parking
- B. Good access by car and public transport
- C. Highly accessible by car but less so by public transport

Many Dutch local authorities appear to have graded sites in the 'B' category to allow flexibility in providing for car use<sup>109</sup>.

#### **Conclusion**

Controlled parking zones in city centres are a potentially important policy measure, although problems of enforcement arise, together with the potentially undermining factor of PNR parking. Data on PNR parking is non-existent or, at best, incomplete.

#### **Quick win**

An analysis of several towns or cities with CPZs could be carried out, looking at issues such as enforcement, and the role and levels of PNR parking, within the context of an understanding of how the place's strategies have evolved over time.

### **4.3.5 Park & Ride (P&R) Facilities**

#### **Research Question 9**

Does research indicate that P&R increases or decreases the distances travelled in cars?

To encourage the use of public transport, additional parking spaces might be provided outside urban areas to for drivers to Park-and-Ride (P&R). P&R is seen as one means of securing access to congested town and city centres while maintaining the flexibility of car use and ensuring that visitors from as wide a catchment area can reach shops and employment etc. The question of whether P&R schemes reduce traffic is often studied in the literature.

Despite growing accessibility problems, P&R facilities do not always attract the expected number of car drivers and are often underused. Why? Research was undertaken in Nijmegen by Bos *et al*<sup>110</sup> involving a stated preference experiment to model P&R choice using the hierarchical information integration (HII) approach with a wide range of attributes. Drivers who had just parked were approached while drivers working, but living outside the town, were contacted via their firms. This research suggested that the success of a P&R facility is influenced by the quality of public transport connecting the P&R with the destination of the traveller.

The results showed that the certainty of a seat was the most important attribute in the decision relating to 'quality of connecting public transport'. The success of P&R facilities depended ultimately on integrated policies that not only improved the quality of the P&R facility itself but also improved the quality of the full multimodal chain and discouraged the use of the car in the city centre. The willingness of car drivers to use P&R also increased if the extra travel time when using P&R was low. Offering high-speed connecting public transport, realised, for example, by a dedicated (bus) lane to the city and enabling efficient transfer at the P&R facility could produce this low extra travel time.

In a literature review examination of the potential for mode transfer of short trips Mackett and Robertson<sup>111</sup> found that P&R and restrictions on cars in town centres can

<sup>109</sup> The Demand for Public Transport, R Balcombe (Editor), TRL, 2004

<sup>110</sup> The Choice of Park and Ride Facilities: an Analysis Using a Context-Dependent Hierarchical Choice Experiment, I Bos, R Van der Heijden, E Molin, H Timmermans, Environment and Planning A, volume 36, 2004

<sup>111</sup> Potential for Mode Transfer of Short Trips: Review of Existing Data & Interactive Sources, R Mackett and S Robertson, UCL for DETR2000

reduce car use. Nevertheless they also argued that car parks are needed next to bus and railway stations.

Parkhurst<sup>112</sup> conducted an appraisal of nine P&R case studies in the UK and their effect on traffic. He concluded that although some studies seemed to provide reassurance that P&R can have traffic-reduction benefits, the main effect of the P&R schemes was traffic redistribution rather than reduction. In terms of policy, it is unlikely therefore that the schemes have a direct effect on traffic reduction. In his study of Oxford, Parkhurst<sup>113</sup> reckoned that P&R maintained accessibility and limited the increase in car trips to the city centre, but did not actually reduce car trips and may lead to a loss of bus patronage outside the city.

Parhurst also introduced the concept of Link-and-Ride<sup>114</sup>. Aimed at edge of urban area P&R facilities which, according to the author, led to a net increase in vehicle-kms travelled and consequently in carbon emissions. Link-and-Ride P&R is based on a chain of smaller interchanges served by an existing, but enhanced, public transport route. The aim is to improve the interception of passing vehicular traffic while minimising both the costs of providing P&R car parks and the need to introduce new bus services. It involves a longer-range scheme with parking capacity integrated with established, rather than specially provided, public transport services along the route. In other words there would be a series of P&R parking sites along a route which could be served by several bus services rather than one dedicated service. In this way it would operate rather like a commuter railway line. Parkhurst claimed that Link-and-Ride would be more cost-effective than traditional models of P&R. Link-and-Ride schemes maintain the accessibility of traditional urban centres and relieve congestion, but at the cost of public subsidies. A higher subsidy would be required for Link-and-Ride than edge of urban area P&R if patronage reaches 400 return trips a day but a greater financial surplus would be generated if more than 1200 trips were generated. No evidence was cited of its practical application however.

A Parking Location Model<sup>115</sup> was developed as part of a study of York's traffic and parking needs to the year 2006. The study aimed to evaluate highway improvements, parking supply and tariff policies, P&R services and to improve facilities for pedestrians, cyclists and public transport services. Based on surveys, a procedures package was developed which was made up of the SATURN Traffic model, the Parking Location Model and the Parking Traffic Model. The Parking Traffic Model was limited to publicly-available parking. The structure was based on an existing assignment model, MICROTRIPS; the main inputs of data included origin and destination data, details of car parking availability and car park tariff levels. The flexibility of the model allowed tests to be conducted with various combinations of parking supply, tariffs and P&R provision. As a result of this modelling the recommended strategy for York included an 80% increase in short stay places (involving a removal of long-stay commuter parking) and a strong emphasis on P&R schemes.

Likewise in Canterbury a P&R scheme was introduced in association with other sustainable transport improvements including bus priority measures<sup>116</sup>. The PARC (P&R in Canterbury) strategy recommended using two P&R for long-stay parking, retaining some city centre car parks and introducing on-street controls for short-stay parking. Data was collected by the Council, including parking surveys. Postcard surveys of P&R users were undertaken. From 1980-91 urban traffic levels grew by an average of 5.7% pa but after the PARC strategy was introduced from 1991-95 traffic levels fell by 6.5%.

<sup>112</sup> The Economic and Environmental Roles of P&R, G Parkhurst, WP 98/15 University College London, 1998

<sup>113</sup> The Environmental and Modal-Split Impacts of Short-range P&R Schemes, Evidence From Nine UK Cities, G Parkhurst, WP research report 96/29, 1996

<sup>114</sup> Link-and Ride – a Strategy for Car-bus Interchange, G Parkhurst, Traffic Engineering & Control, 2000

<sup>115</sup> Parking Policy Assessment: the Contribution of a Parking Location Model in York, T May, D Jones and J Rigby, Traffic Engineering & Control, 1989

<sup>116</sup> A Review of Canterbury's P&R Scheme, A Roberts, T Parker and A Phillips, ICE Transport Proceedings, 1998

Research in the Netherlands<sup>117</sup> suggested that city centres should cater for short-term parking but that space appeared to be dominated by long-stay users. P&R was categorised into three types split between journey origin and destination (see Table 10 below):

**Table 10: Types of P&R**

	Use of Public Transport	Carpooling
Close to journey origin	Type 1: P&R facilities at public transport nodes, in residential areas, commuter traffic	Type 3: P&R facilities at traffic node e.g. motorway junctions
Close to journey destination	Type 2: P&R facilities at public transport nodes, on outskirts of urban area, commuter traffic and long-distance	Non-existent

Type 2 P&R facilities depend on the level of congestion likely to be encountered closer to the destination. Types 1 & 3 entail added benefits of cost savings or more effective use of travel time. In the UK Type 3 P&R is not formalised although some commuters have set up informal systems. The changeover process at a P&R site must be convenient. Maartens also cites the case of when a free car park next to a railway station was replaced by one that incurred charges (€2.50 a day) the use was still 50% lower one year later.

An international review<sup>118</sup> argued that fringe and transport corridor parking may allow each transport mode to be used to the best of its advantage. Fringe parking should be located so that it intercepts home to work trips destined to the CBD. The promotion of P&R needs to be supported by an ample supply of well located fringe parking and high quality public transport.

Parkhurst<sup>119</sup> claimed that while some users had reduced their car use, some were attracted by the P&R opportunity and increased their number of journeys. Looking at two major cities in the UK; Oxford and York, Parkhurst also found congestion in these cities remained the same. He therefore concluded that a package of policies, including further improvements to public transport should be used in order to achieve the desired reduction in total travel. If city centre parking charges had been increased at around the same time this response would have been anticipated.

There is little evidence of a reduction in traffic or demand for town centre parking as a result of P&R schemes<sup>120</sup>. While P&R provision encourages public transport use its effect is not as positive as improvements to rail, light rail or guided busways. For P&R decongestion benefits to be realised it is important that provision does not lead to an overall increase in parking spaces in the city which could be used by the, currently, suppressed demand.

<sup>117</sup> P&R Facilities: Planning Practice, Maartens, Parking Trend International, 2004

<sup>118</sup> International Approaches to Tackling Transport Congestion, Booz Allen Hamilton, 2006

<sup>119</sup> The Environmental and Modal-Split Impacts of Short-range P&R Schemes, Evidence From Nine UK Cities, G Parkhurst, WP research report 96/29, 1996

<sup>120</sup> The Demand for Public Transport, R Balcombe (Editor), TRL Report 593 para 3.6.3, 2004

### **Conclusion**

Much research has been undertaken into the impact of P&R. But while P&R is a popular policy the research evidence identifying its benefits appears unclear: while it may extract traffic from town centres it may also encourage longer car journeys to access the facility. Much will depend on the circumstances in which it is introduced.

### **Quick win**

A practical trial of a link-and-ride scheme, together with an evaluation of its impacts, could form a useful addition to the knowledge base.

### **4.3.6 Railway stations**

#### **Research Question 10**

Does the provision of parking at railway stations encourage more use of rail or are the adverse impacts damaging?

The Passenger Demand Forecasting Handbook<sup>121</sup> has set out three possible scenarios where station parking is limited:

- 1) Stations with obvious existing alternative parking facilities;
- 2) Stations where another nearby station has a large car park; and
- 3) Stations with no single obvious alternative parking facility.

In response to these scenarios drivers are expected either to park away from the station, use an alternative e.g. the bus or 'kiss and ride', use another station or not to travel by train.

Nationally, around a fifth of rail users travel by car to their origin station<sup>122</sup> and poor availability of car parking is often cited as a problem in surveys of rail passengers, achieving a 44% satisfaction score in the National Passenger Survey<sup>123</sup> undertaken by Passenger Focus in 2009. The bi-annual National Passenger Survey involves over 26,000 questionnaires in each wave distributed at approximately 700 stations across Great Britain. Some 21% said that car parking was important to have at stations and 16% thought that it needed improving.

As parking at railway stations involves a change of mode, drivers are influenced by factors relating to interchange in addition to those specifically related to parking that have already been discussed. McDonald et al<sup>124</sup> cites numerous studies showing that interchange of any kind is widely recognised to be a barrier to the use of rail, which is reflected in greater values being attached to time spent in access modes, and in interchange, than on the train. This is known as the interchange penalty and represents the risks arising from delay in the access mode, in particular of missing onward connections (see Bates *et al*<sup>125</sup>; Wardman and Hine<sup>126</sup>; and Wardman<sup>127</sup>).

<sup>121</sup> Passenger Demand Forecasting Handbook, Association of Transport Operating Companies, 2002

<sup>122</sup> National Rail Travel Survey Final Report, DfT, 2008

<sup>123</sup> National Passenger Survey, Passenger Focus, 2009

<sup>124</sup> The Role of Rail in Integrated Transport, M McDonald, J Crockett, M Beecroft, C Nash, B Menaz, T Fowkes, Rail Research UK RRUUK/C3/1, 2003

<sup>125</sup> The Valuation of Reliability for Personal Travel, J Bates, J Polak, P Jones, A Cook, Transportation Research Part E: Logistics and Transportation Review Volume 37, Issues 2-3, April-July 2001, Pages 191-229, 2001

Consequently, time spent searching for parking spaces and uncertainty that one will be found in time leads to a risk that onward connections will be missed and may discourage people from making the journey by rail. As a result, McDonald et al argue that *"it is not the use of rail for the main leg of the journey that is the major cause of inconvenience as opposed to car travel but rather the accessing and egressing of the rail network"*<sup>128</sup>. Thus it would follow that improvements to the access mode, including of station car parking, have the potential to increase the use of rail without needing changes in the rail service, a conclusion supported by studies carried out in the Netherlands, for example in Brons *et al*<sup>129</sup>. They concluded that *"in many parts of the rail network improving and expanding access services to the railway station can substitute for improving and expanding services on the rail network, and that it is probably more cost efficient when the aim is to increase rail use"*. In a cautionary note however, a study for the former UK Strategic Rail Authority found examples of improved car parking provision being used mostly by passengers diverting from other stations rather than by new passengers who would otherwise have completed their full journey by car. At Warwick Parkway for example, only 15% of passengers were new to rail<sup>130</sup>.

Travel to stations is innately multi-modal and the literature referred to above is not solely focused on car parking, but also considers alternative modes of access. Car parking at stations is often constrained by available space which is in competition with other potential uses, such as space for taxis and buses, drop-off space, cycle parking, or even non-transport use such as retailing. Lack of parking spaces can lead to overspill parking into surrounding streets, causing problems elsewhere. Furthermore, as has been discussed earlier, commuters occupy parking spaces for far longer than other types of traveller, so if the available parking spaces are taken by commuters then it will be harder to attract off-peak passengers, even though this is very desirable to maximise use of rail capacity. Rail operators therefore have an interest in making most efficient use of their parking spaces by encouraging alternative access modes to their stations, which has led to the concept of Station Travel Plans (STPs). A pilot programme of STPs is being led by ATOC and Passenger Focus, with an initial report of baseline travel data published in 2009. Further research in this area will be possible as the STP programme develops.

The Station Travel Plan Data Report identified uncertainties about how drivers respond to changes in parking availability as a knowledge gap and recommended survey methodologies to identify whether drivers divert between different stations, or change mode completely.

In a review of parking provision at stations in London and the South East, Niblett and Palmer<sup>131</sup> pointed out that P&R is a significant and growing means of access to stations but that demand for P&R outstrips supply. Over half the 950 stations in the South East have their own station car park; 73,000 parking spaces are available. In addition the (then) London Underground Ltd (now TfL) has car parks at 65 of 250 stations, with 12,000 spaces. Limited opportunities for expanding rail-based P&R existed in London they concluded, especially for multi-storey car parks, except with developer contributions. The success of rail-based P&R depended on the location of the site. Furthermore the location of parking, parking charges, and the relative quality of the train service, could lead to "rail-heading" whereby passengers drive to a station with better rail services than the closest one, e.g. from Harpenden to St Albans, for journeys into

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<sup>126</sup> Costs of Interchange: a Review of the Literature, M Wardman and J Hine, Institute of Transport Studies, University of Leeds, 2000

<sup>127</sup> A Review of British Evidence on Time and Service Quality Valuations, M Wardman, Transportation Research Part E: Logistics and Transportation Review, Volume 37, Issues 2-3, April-July 2001, Pages 107-128, 2001

<sup>128</sup> The Role of Rail in Integrated Transport, M McDonald, J Crockett, M Beecroft, C Nash, B Menaz, T Fowkes, Rail Research UK RRU/C3/1, 2003

<sup>129</sup> Access to Railway Stations and its Potential in Increasing Rail Use, M Brons, M Givoni, P Rietveld, Transportation Research Part A 43 (2009) 136-149, 2009

<sup>130</sup> SRA Station Parking Study, Strategic Rail Authority, Scott Wilson, 2002

<sup>131</sup> Park and Ride in London and the South East, R Niblett and D Palmer, Highways and Transportation, 1993

London. (“Reverse rail-heading” involves driving away from one’s destination to secure a better rail service). However, little information exists about such behaviour other than anecdotal evidence.

An SRA Station Parking Study<sup>132</sup> argued that parking could help boost rail use, but that there were concerns about unintended effects, such as extracting demand from other stations, creating congestion around stations, undermining pedestrian and cycle access and using land otherwise available for sustainable development. The report highlighted that, for most issues, there were positive and negative arguments, and their resolution could depend on local circumstances. Relatively little empirical evidence was reported to be available. European research was quoted on typical distances travelled by different feeder modes, together with a methodology for classifying station catchments. Bus-based P&R research was quoted, with the conclusion that the location and user costs of rail parking could be central to its desirability. Regional research was quoted about the proportion of people using new rail parking who would otherwise have driven for all their journey (22% according to Greater Manchester PTE; 18% West Midlands; 17% Strathclyde PTE; >15% Warwick Parkway). 70% of trips at Warwick Parkway were reported to have previously been made by rail from more local stations. The report recommended that future work should comprise a number of case studies, examining the main issues relating to station parking arising at public inquiries, and how these were resolved. Five station types were identified for assessment – parkway; inter-urban; peripheral; local urban and local rural.

In a follow-up study<sup>133</sup> eight issues were highlighted with which the SRA was most concerned. Factors leading to station parking approval included:

- Significant amounts of high quality, conclusive data to address issues;
- Demonstrated demand for new parking;
- Positive/minimised-negative traffic and economic impacts;
- Positive/minimised-negative impacts on other stations;
- Compatibility with national and local policy;
- Commitment from the train operating company, local authority and other relevant local bodies;
- Rigorous consideration of alternatives to increasing parking; and
- Good design to minimise visual impacts (especially in greenbelt land).

In reality, only three of the proposals presented significant quantitative evidence about traffic impacts, (and after monitoring at Warwick Parkway indicated that their forecasts were wrong – only 15% of new trips were previously made by car compared to a prediction of 75%). The study recommended further research including detailed analysis of parking provision at two case study stations, (one inter-urban; one peripheral), where the balance between P&R and completing the entire journey by train was finely balanced. Furthermore the SRA indicated that understanding could be taken forward in a variety of different ways, including assessing the value of providing station parking; identifying ‘ideal’ levels of parking provision for different types of catchment; reviewing regulatory and funding mechanisms for parking provision; developing guidance on station design; and assessing the potential for managing station parking as part of wider local transport strategy.

A study which examined travel pricing scenarios using two urban models drew together a variety a land use and transport policies to reduce vehicle miles travelled and emissions<sup>134</sup>. One of the conclusions of this research was that pricing measures should not be imposed in areas served by light rail.

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<sup>132</sup> SRA Station Parking Study, Strategic Rail Authority, Scott Wilson, 2002

<sup>133</sup> Station Parking Study Stage 11a – Identification of Research Priorities, Scott Wilson, 2003

<sup>134</sup> Heuristic Policy Analysis of Regional Land Use, Transit, and Travel Pricing Scenarios Using Two Urban Models, C Rodier, R Johnston and J Abraham, Transportation Research, 2002



A recent study by ATOC<sup>135</sup> undertook a number of surveys and analyses of elasticities across a tranche of busy stations in the UK. They concluded that provision for parking is in line with demand, except at the biggest city centre stations. Moreover, they also encouraged train operators to review pricing of car parks, particularly where alternative parking is available.

#### **Conclusion**

Interchange penalties are an important deterrent to rail travel and combined with the waiting time may discourage public transport use. Parking is therefore potentially needed at railway stations as well as at appropriate drop off areas for “kiss and ride” commuters. However, parking provision may also encourage undesirable behaviour, such as extracting demand from other stations, creating congestion around stations, undermining pedestrian and cycle access and using land otherwise available for sustainable development. Hence, this is a complex issue, worthy of further research.

#### **Quick win**

It might be useful to develop a typology of different types of stations, and different types of locations, in order to identify the levels of parking which could be appropriate in different situations.

### **4.3.7 Shopping centres**

#### **Research Question 11**

Is parking availability or price key to the selection of one shopping centre rather than another?

Parking at shopping centres differs to that in town centres; whereas town centres usually accommodate both long and short stay parking, shopping centres tend to focus on the latter.

In work for TfL, in February 2005, Accent<sup>136</sup> conducted 120 interviews in Kingston and 48 interviews in Feltham with ‘shoppers who drive and park’. People were asked about their willingness to pay for parking and, then, what their reaction would be if parking charges were increased (to £1.60 an hour in Kingston, and 68p per hour in Feltham). The results suggested that only 32% of driving shoppers to Kingston would have continued to drive and park in the area (with 68% of people saying they would adapt their behaviour in some way). In Feltham, only 25% of people said that they would have continued to drive, park and shop in Feltham if parking charges were increased.

According to the RAC survey<sup>137</sup> shoppers are particularly sensitive to the cost of parking – it is often the only marginal cost for a car journey as ownership costs such as tax and insurance are fixed and the cost of petrol is not attributed to a particular journey.

Codd<sup>138</sup> developed and evaluated a parking requirement prediction model, based on shopping centre size and car ownership in catchment area. He suggested that parking standards take account of shops acting as shopping centre groups rather than treating individual shops separately and that there is often little to justify existing parking standards. A sliding-scale parking standard, the rate of provision varying with gross floor area, performed almost as well as a predictor of demand as a more complex prediction model. All the parking standards examined would have been improved if expressed as ranges of provision since it would then be possible to take account of

<sup>135</sup> Car Parking at Railway Stations, Association of Train Operating Companies, 2010

<sup>136</sup> Town Centre Parking, Report to Transport for London, Accent, 2005

<sup>137</sup> Shopping and Transport Policy, RAC, 2006

<sup>138</sup> Parking Requirements at Suburban Shopping Centres - an Investigation, V Codd, Traffic Engineering & Control, 1983

additional 'unmodelled' factors. These included 'location' vis-a-vis the road network hierarchy and shopping centre 'character' or 'style of operation'. It recommended that phased construction of larger car parks could overcome some of the problems inherent in forecasting demand. However, current literature advocates more effective parking management rather than increasing supply, which is limited in urban areas.

Bacon<sup>139</sup> developed a model of shopping behaviour to include the effects of congestion with an illustration for a single, hypothetical, shopping centre. Parking suffers from congestion in terms of the increased time and difficulty of finding a space at a time when many others are using the same centre. Models which include a fixed cost of parking, according to Bacon, implicitly assume that there is such a large supply that the chance of finding a space is not affected by changes in the overall frequency of shopping. For city centre shopping this is considered unrealistic. Improvements in road and parking capacity can be expected to generate more traffic as the costs of shopping trips are lowered. Improvements in parking are much more likely to be asymmetric in their effects – improvements in the road system will generally improve access to several centres, while parking charges are implemented individually (by individual shopping centres). Congestion in parking is more acute for shoppers than commuters, according to Bacon. Parking capacity can have large effects on traffic even where there is no trip diversion to other centres. Elasticities were determined from a hypothetical example (see table 12 below).

**Table 12: Elasticities with respect to Travel Parameters – example for a single shopping centre**

	Frequency of shopping at city edge	Total traffic arriving at centre	Total travel cost per trip at city edge	Total parking cost per trip
Road capacity	+0.031	+0.023	-0.213	+0.010
Parking capacity	+0.179	+0.208	+0.049	-0.457
Travel costs without congestion effects	-0.150	-0.083	+1.000	+0.000
Travel costs with congestion effects	-0.116	-0.057	+0.980	-0.031
Parking costs without congestion effects	-0.380	-0.450	+0.000	+1.000
Parking costs with congestion effects	-0.319	-0.362	-0.092	+0.811

Bacon concluded that the impacts of changes in travel and parking costs have a substantially smaller effect once the feedback from congestion is taken into account.

Kelly undertook a before and after study of one hypermarket in Caerphilly<sup>140</sup>. The spread of design rates for visits to out-of-town superstores and hypermarkets had previously been suggested as 30-50 trips per 1000 sq ft of gross leasage area. Monitoring of the Carrefour hypermarket, Caerphilly, from its opening in September 1972 indicated a wider range. However, a closer relationship occurred when visitation

<sup>139</sup> A Model of Travelling to Shop with Congestion Costs, R Bacon, Journal of Transport Economics and Policy, 1993

<sup>140</sup> Parking at a Hypermarket - Six Years on, R Kelly, Traffic Engineering & Control, 1982

rates were related to retail area. The author recommended that rates ranging from 80 to 90 entry trips per 1000 sq ft of retail area be used, the lower level applying to hypermarkets and superstores without such additional facilities as a petrol filling station and the higher level applying when such facilities are present. Parking ratios of 10 to 15 spaces per 1000 sq ft of retail area were recommended.

The importance of parking to the retail industry was identified by a study in Tonsberg, Norway<sup>141</sup>. A customer survey of 601 people showed that nearly 65% of shoppers were car drivers or passengers, but they represented over 80% of the turnover; 20% were public transport users who accounted for 12-13%. Nearly 2/3 thought that finding a parking space was easy. Tönsberg had a policy to achieve 86% utilisation of parking spaces.

In the USA, and perhaps in some places in the UK, parking charges are bundled with access to certain shops or services. Bundling is a form of direct price discrimination, according to Lan and Kanafani<sup>142</sup>. Based on a theoretical review that involved the development of a mathematical model to determine social welfare they argued that if market prices for both items (parking and shopping) are determined by a no-bundling approach, a switch from no-bundling to mixed-bundling increases consumer surplus.

When people or retailers are asked directly about parking, it often comes across as seeming important - but in wider surveys, it tends to be the quality of the shopping environment which is a more important determinant on where people go, and their satisfaction with their visit<sup>143</sup>.

### **Conclusion**

The research suggests that it is not just parking charges that influence shoppers' behaviour.

### **4.3.8 Workplaces**

#### **Research Question 12**

Is there sufficient research to demonstrate the impact of free PNR parking upon travel behaviour?

Free work place parking has long been considered to have a strong influence on whether or not individuals use their car for their trips to work. The granting of planning permission for developments containing large amounts of off-street parking, and for privately-funded car parks, has meant that it is now impossible to control how this space is used<sup>144</sup>. The inability to exercise control over the use of PNR parking space is an issue which potentially limits the wider use of parking controls as part of demand restraint strategies in congested urban areas.

An analysis of company travel assistance in central London, was undertaken by Hudson and Kompfner<sup>145</sup>. A sample survey of 7,400 car commuters with destination in central London was undertaken. Its objectives were to identify in central London:

- (1) parking supply by type of facility;
- (2) parking demand (here defined as observed parking usage) and trip characteristics of terminating cars;
- (3) the extent of company parking assistance by type of parking facility;

<sup>141</sup> Tönsberg, Norway; Parking is Most Important for City Centre Commerce, K Oedegaard, Parking Trend International, 2005

<sup>142</sup> Economics of Park and Shop: A Case of Bundled Pricing Strategy, L Lan and A Kanafani, Journal of Transport Economics and Policy, 1993

<sup>143</sup> Traffic Restraint and Retail Vitality, Sustrans, 2003

<sup>144</sup> Parking Perspectives, MVA for DfT, 1993

<sup>145</sup> Car Parking in Central London, R Hudson and P Kompfner, Traffic Engineering & Control, 1993

- (4) the balance of parking supply and usage;
- (5) whether parking spaces are being used efficiently.

The authors contended that the use of parking facilities by company cars, private cars, journey purpose, and employment status were estimated. They calculated that 82,000 of 105,000 parking spaces in London were off-street. Over half of off-street spaces were PNR parking - 41% of all spaces. Evidence suggested that the availability of a parking space or subsidised parking was more likely than the existence of company cars to encourage trips by car. In particular, company parking space encourages commuting trips with low vehicle occupancy when the road network is most congested. The study observed that 63% of peak period commuters park at a firm's car park, and 21% at a public car park. At both these types of off-street location, almost 90% of commuters stay at least seven hours. Evidence from the extensive use of yellow lines suggested that there was insufficient short-term parking spaces for business and non-work trips. Drivers perceived the public transport alternative as having too many disadvantages. It must be acknowledged that public transport has significantly improved in London since this survey was conducted in the early 1990's.

In 1993 the London Planning Advisory Committee (LPAC)<sup>146</sup> devised a matrix of parking standards for financial and professional services and business uses (given that the majority of trips generated by these two land uses are to work, most of which are likely to be peak hour trips). The public transport accessibility of any development site would be assessed to determine the degree to which public transport could be used as an alternative means of transport. The level of public transport accessibility would then be reflected in the parking standards, and have a role in determining the level of parking provision to be made on the site. LPAC initially envisaged a strategic role for the matrix i.e. to provide the basis for a co-ordinated application of standards across London. A higher level of demand restraint could be applied in central London, which has good public transport accessibility. A lower level of restraint would be applied in outer London, where the level of public transport accessibility is lower. It was realised that to be successful in practice that a co-ordinated approach by all of the London boroughs would be necessary.

In 1992, SERPLAN's Transport Strategy Group set up a Parking Study, to examine how parking policy, with many other planning measures, could be used to implement an overall policy of reducing total travel demand. In the SERPLAN study, Foster and Eastman<sup>147</sup> conducted and analysed surveys of parking demand and modal choice at a range of office developments in South East England; 59 sites were surveyed, and questionnaires were sent to about 23,000 employees, of whom about 62% replied. The sites were located at:

- (1) town centre cores;
- (2) town centres;
- (3) town suburbs; and
- (4) rural areas.

Analyses were made of:

- (1) employment densities;
- (2) arrival and departure patterns;
- (3) journey times;
- (4) parking provision; and

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<sup>146</sup> Advice on a Parking Strategy for London (Supplementary Planning Advice), London Planning Advisory Committee, 1993

<sup>147</sup> Parking and Public Transport - the Effect on Mode Choice: a Study of B1 Developments, M Foster and C Eastman, Traffic Engineering & Control, 1993

- (5) modal split, especially in relation to parking provision and public transport provision.

The study was designed to estimate how public transport provision and parking restraint might affect the modal split for journeys to and from work. Although of restricted scope, the study provided extensive data. The paper discusses several theories and issues, relevant to the current debate on finding ways to reduce the need to travel. They include:

- (1) the effect of employment density;
- (2) the effect of journey times;
- (3) the role of public transport;
- (4) the role of parking restraints; and
- (5) the effect of carbon dioxide (CO<sub>2</sub>) emissions.

Its findings suggested that there may be greater scope for car-sharing schemes, home working, flexible work and school hours, etc.

A study in Glasgow<sup>148</sup> set out to assess the number of PNR spaces in the city centre and their contribution to peak-hour traffic. Site surveys were undertaken of 374 car parks that comprised 7,239 spaces in total. Morning peak hour (8-9am) into the city centre was 2.4 times greater than the daytime average. PNR parking represented 42% of the overall parking stock; it had risen over the previous decade as new developments had been constructed. The policy of pricing public off-street parking to deter all-day parking appeared to be working. Finally the survey indicated PNR parking on sites for which no planning permission existed.

Foster and Eastman<sup>149</sup>, who undertook the Glasgow study, concluded that there are more parking spaces out-of-town: 1 space to 27m<sup>2</sup> out-of-town; compared to 1 space to 69m<sup>2</sup> in town. Around 70% of employees arrived in the morning peak while 65% left in the evening peak. The average car trip length was 26 mins compared to 47 mins by public transport. Of those employers surveyed 90% said that parking was most essential feature of their office; 75% needed 1 space per employee while 25% wanted more.

In an *Assessment of Parking Demand*<sup>150</sup> the TRICS database was interrogated to enable a much more comprehensive review of parking demand to be performed. The TRICS database contains site information, traffic flows and parking accumulation information for several land uses. The sites studied included food and do-it-yourself superstores, retail parks, offices and business parks. At most sites, parking provision was considered just adequate, but at a few it tended to be over-generous especially at retail parks and business parks. Calculation of a parking demand ratio for each site was based on its gross floor area, divided by the maximum parking accumulation (arrivals less departures) at the site. The authors concluded that a maximum of 1 space per 20m<sup>2</sup> at retail parks could be replaced with 1 space per 30m<sup>2</sup>.

Perhaps surprisingly, free, or subsidised, parking may not necessarily be the most important reason for car commuting. Otlet<sup>151</sup> surveyed seven workplace locations, including three medical centres, in Nottingham, Leeds, Harrogate, Oxford and Bristol. The aim was to identify the barriers which car commuters believed prevented them from using an alternative method of getting to work. Interviews generated 161 responses and 713 came from surveys. This showed that free or subsidised parking was only 12th in importance (out of 18) of reasons for commuting by car – it being too far to walk or

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<sup>148</sup> Measuring the Effect of PNR Parking on Peak-hour Traffic Levels in Glasgow City Centre, P Dorby and T Rye, Traffic Engineering & Control, 1999

<sup>149</sup> Parking and Public Transport - the Effect on Mode Choice: a Study of B1 Developments, M Foster and C Eastman, Traffic Engineering & Control, 1993

<sup>150</sup> An Assessment of Parking Demand, G Mackenzie and C Eastman, Traffic Engineering & Control, 1992

<sup>151</sup> The Barriers to Change as They are Perceived by Commuters, G Otlet, Traffic Engineering & Control, 2001

cycle being the main reason. Although the results varied by site, should parking become unavailable up to 90% said that they would continue to drive but park elsewhere, and up to 26% would change job. 56% would pay up to £3 per day for their current parking; 6% would pay more. According to this survey females tended to value their cars more highly than males because of the errands they run.

One way of changing employees' travel behaviour through workplace parking was suggested by Shoup<sup>152</sup>. Shoup reviewed eight American companies using the cash-out programme; an option which is required by California law which allows commuters to choose cash in lieu of any parking subsidy. Shoup concluded that the cashing out of employer-paid parking could have many benefits to employers, employees and the environment. In particular, he found that:

- The number of those who walk or cycle to work increased by 39%;
- Carbon dioxide emissions from commuting fell by 367 kg per employee per year; and
- The number of those who car share to work increased by 64%.

In England, the cash-out scheme is utilised by Pfizer, a Pharmaceutical company in Kent as part of its travel plan. The scheme has not yet been fully validated but the company has reported that the travel plan as a whole contributed to a reduction in cars to people ratio.

A per-space parking levy (a special property tax applied to parking facilities) is more challenging to implement because it requires an inventory of qualifying parking facilities, but it encourages property owners to reduce parking supply (particularly seldom-used spaces) and manage their parking supply more efficiently, and it encourages pricing of parking. As a result, it encourages more compact, accessible, multi-modal land use patterns and reduces sprawl. Its cost burden is more evenly distributed<sup>153</sup>.

### **Conclusion**

The research demonstrates that the provision of, usually free, PNR parking spaces is very important in determining travel behaviour.

#### **4.3.9 Workplace Travel Plans (WTPs)**

There have been a large number of studies investigating the attitudes of employers and employees to workplace travel plans (WTPs) for example by Rye<sup>154</sup> and green commuter plans for example by Coleman<sup>155</sup>. However, very little is known about employers and employees' attitudes to parking related measures such as parking levies and cash-out schemes.

The questionnaire survey and focus groups used by Rye indicated that employee parking is a delicate political issue and that reducing the number of spaces, or access to them, can cause great difficulties. In Holland, when introduced as part of a package including better benefits (in particular) for cyclists, the WTP is easier to sell to the whole workforce and unions than it might be in the UK where very many fewer people cycle to work.

A literature review followed by a postal questionnaire sent to a sample of small businesses (under 100 employees) in Oxfordshire was undertaken by Coleman. Investigation of the attitudes and policy of small employers towards staff travel and

<sup>152</sup> Evaluating the effects of cashing out employer-paid parking: Eight case studies, Transport Policy 4, D Shoup, 1997

<sup>153</sup> Parking Taxes: Evaluating Options and Impacts, T Litman, Victoria Transport Planning Institute, 2010

<sup>154</sup> Employer Attitudes to Employer Transport Plans: a Comparison of UK and Dutch Experience, T Rye, Transport Policy 6, 1999

<sup>155</sup> Green Commuter Plans and the Small Employer: an Investigation into the Attitudes and Policy of the Small Employer Towards Staff Travel and Green Commuter Plans, C Coleman, Transport Policy 7, 2000

green commuter plans indicated that basic company policy is geared towards promoting car use. The high provision of staff car parking, together with policies such as the requirement to have a driving licence, promotes car use.

In a forthcoming journal paper, Cairns, Newson and Davis<sup>156</sup> describe a study of 20 companies with WTPs (Workplace Travel Plans) to identify factors to encourage modal shift. Best practice case studies were selected from previous reviews; telephone interviews and staff surveys were also undertaken. They concluded that organisations that had addressed parking in some way had achieved more than double the reduction in car use than those that had not, and had car driver levels which were, on average, 25% lower. While restricting the proportion of staff entitled to park was seen as a more direct method of discouraging car use (rather than charging) introducing incentive payments for those not driving to work had often helped in achieving higher than average levels of behavioural change. Parking criteria – based on need rather than seniority – were seen as fair. According to Cairns et al WTPs were seen as alleviating or avoiding parking pressures and therefore save money – the DfT were cited as estimating running a parking space as £300-500 pa.

A survey of local authority employees in Dublin was conducted to examine their potential responses to the removal of free workplace parking spaces, how they would respond to parking cash-out policies and to workplace parking charges, and finally their responses to specific values of cash-out payments<sup>157</sup>. A web survey of local authority employees was undertaken; 473 responded. Of the respondents 58% regularly drove to work (51% alone with 7% taking passengers), 16% regularly took the bus and 7% regularly went to work on the train. The study found that as age increased individuals were less likely to accept any form of cash-out. Individuals who had one or more cars available were more likely to opt for a cash-out scheme. Females were also more likely to opt for the various cash-out schemes than males (apparently contradicting the results of Otlet<sup>158</sup>). The results seemed to suggest that if an individual has a higher income it does not necessarily mean they will opt to keep their space. Looking at the results of the behavioural responses to a suggested €5/day charge to park at work, a relatively large group of individuals (31.5%) would still travel to work by car. It can be noted from the results that the policy of cash-outs might only influence part of the population; about 30% gave a high preference to giving up their space for a year and receiving a payment in lieu. This particular result was higher than the authors expected. On the basis of this result, even allowing for the possibility of the halo effect (a belief that drivers are responding positively to societal needs), the authors considered that the result was sufficiently positive to suggest that 'cash-outs', as part of an integrated package of demand management measures, could deliver a reduction in car use. However, the study did not find a link between individuals' income and their willingness to pay for a parking space.

Shoup and Willson<sup>159</sup> estimated the cross elasticity to be 0.35 using a multinomial logit model in the Los Angeles CBD. Offering the cash option to employees who received employer-paid parking would reduce their SOV driving by 20%, and the number of vehicle miles travelled per employee by 17%.

### **Conclusion**

Workplace parking regulation, pricing and cash-out schemes are also likely to influence commuters' travel choices.

<sup>156</sup> Understanding Successful Workplace Travel Initiatives in the UK, S Cairns, C Newson and A Davis, Transportation Research A, 2010 (forthcoming)

<sup>157</sup> Response to Cash-outs for Workplace Parking and Workplace Parking Charges, P Watters, M O'Mahony, B Caulfield, Transport Policy, 2006

<sup>158</sup> The Barriers to Change as They are Perceived by Commuters, G Otlet, Traffic Engineering & Control, 2001

<sup>159</sup> Commuting, Congestion and Pollution: The Employer-Paid Parking Connection, University of California, 1992

**Quick win**

A Revealed Preference of sites, in different types of area, where a cash-out option has been implemented could identify their effectiveness in reducing commuter car use.

**4.3.9.1 Workplace-parking levies (WPLs)**

**Research Question 13**

Does the research indicate that the introduction of WPL would lead to less car commuting, more public transport use and hence environmental benefits?

Given the importance of the availability of free PNR parking in encouraging car commuting, WPLs have been suggested as a fiscal measure to discourage SOV use.

In a three-stage Delphi study of 22 business leaders in Nottingham<sup>160</sup> the effects of WPL and road-user charging were predicted over 24 years. The panel was selected on the basis of their familiarity with the local economy and due to their ability to provide objective and thoughtful analyses. They concluded that prime and secondary offices and manufacturing would be the sectors most adversely affected and for the longest duration by the introduction of WPLs, primarily owing to the substantial commuter car parks in these sectors. However, by year 2 the benefits brought about by improvements to public transport and the environment were expected to begin to ameliorate these negative impacts so that by the medium term (six to ten years), the WPL would be relatively innocuous in these sectors. In the long term (twelve to twenty years), modest positive impacts on output ranging between 0.6% and 1.3% for manufacturing and offices, respectively, are expected, as the increased public transport service levels and environmental improvements reached their full effect.

The Delphi members noted that institutional users had substantial commuter car parks, as did convenience/bulk retail holdings that were located out of the city centre. However, comparative retail activities located within the city centre have very little, if any, commuter parking. Over time the improvements in performance that resulted from the WPL in all sectors would be modest, ranging from a low of 0.6% for manufacturing to a high of 3.5% for daytime leisure activities. It was also interesting to note that the Delphi panel members believed that certain economic sectors, particularly tourism and leisure, would enjoy net benefits from reduced road congestion and environmental improvements.

Whitehead *et al* reported that a WPL without dedication of the revenue stream to transport and environmental improvements would be seriously negative, perhaps leading to a decline in GDP of up to 18%. But with hypothecation it would generate net benefits (see table 13 below).

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<sup>160</sup> The Whole-Life Impacts of Transport-Charging Interventions on Business Performance: a Time-Marching Framework, T Whitehead, J Preston and T Holvad, Environment and Planning A, volume 37, 2005



**Table 13: Key economic impact results on net present value (NPV) and GDP (mean Delphi, 6% discount rate)**

Scenario	NPV £ (million)	Percentage of city GDP	Percentage of central area
WPL(a)	-786	18	na
WPL(b)	34	1	na
RUC(a)	-380	9	27
RUC(b)	-44	1	3

Key:

WPL(a) workplace-parking levy without hypothecation;  
WPL(b) workplace-parking levy with hypothecation;  
RUC(a) road-user charging without hypothecation;  
RUC(b) road-user charging with hypothecation.

The Nottingham proposal has been controversial however: firms who may have the WPL imposed on them have been critical of the plans according to Osborne<sup>161</sup>. Interviews and a review of publications led him to conclude that businesses lose around £6,000 pa for each staff car parking place they provide. The city has 500 large employers in the public and private sectors, most of which provide free parking.

A study by Mackett and Robertson<sup>162</sup> argued that many households were car dependent i.e. that they rely a car to travel, as there were no feasible alternatives. An investigation of published data showed that over 70% of all trips were <under 5 miles in length and that cars were used for 17% of trips of under 1 mile. Thus congestion charging and a WPL were likely to be more successful than parking controls in reducing traffic and promoting modal shift.

In a nationwide survey<sup>163</sup> of local authority councillors and officials, as well as transport academics, the acceptability of the WPL was tested. The survey provoked 147 responses - a response rate of 57% - considered to be an indicator of interest in the subject. The health effects of traffic were seen to be a problem cited by 66% while 70.5% cited exhaust fumes and urban smog as problems. In terms of addressing these issues, promoting teleworking was deemed to be least effective but improving public transport was seen to be the best by 90% of respondents. Out of 16 options the WPL was ranked third from bottom: only 33% thought that it would be fairly or totally acceptable and 52% thought that it would be fairly or totally unacceptable. Some 25% suggested annual WPL in the range of £500-600, but 66% were in favour of a charge of over £500 for it to be effective.

Combined with road pricing a WPL could be very effective. Research using a four stage model for Belfast indicated that a WPL, with a toll cordon, could increase public transport patronage by 12%<sup>164</sup>.

<sup>161</sup> Workplace Parking, J Osborne, Parking News, 2008

<sup>162</sup> Potential for Mode Transfer of Short Trips: Review of Existing Data & Interactive Sources, R Mackett and S Robertson, UCL for DETR, 2000

<sup>163</sup> Acceptability of WPL is Cause for Concern, S Ison, J Thorne and S Wall, Traffic Engineering & Control, 2000

<sup>164</sup> Energy Trade-offs and Market Responses in Transport and Residential land-use Patterns: Promoting Sustainable Transport Policy, J Cooper, T Ryley and A Smith, Urban Studies Vol 38, No 9, pp 1573-1588

According to Enoch<sup>165</sup> lessons might be learnt from reviewing experience in Perth, Australia (as well as Sydney and Dublin). The Perth Parking Licence Scheme was introduced in 1999 charging \$70 (£25) a year but raised to \$120 (£43). Around 53,000 spaces were licensed and parking supply fell by nearly 10% - there were 6,000 fewer spaces than in 1998. However short-stay public parking in the CBD was increased and a few targeted exemptions permitted. A similar scheme was introduced in Sydney. In general it appeared that employers had assumed the charge but not passed it onto the end users and difficulties arose where more than one employer shared the same car park. Relocation of businesses was not considered to be as much of a problem in Australia as in the UK.

In a comparison<sup>166</sup> of WPLs with other forms of travel demand management, drivers were found to be much more responsive to charges imposed than to other out of pocket expenses. The SATURN-based study included SATEASY for assignment routines and ROAD-FAC (part of TEMMS) for environmental indicators. It focussed on three cities: Cambridge, Norwich and York – all members of the UK Historic Towns Forum. Around 4,250 Stated Preference questionnaires were analysed. Results from the business survey of 197 firms showed that 13% of employers said they would pass on a WPL to employees, 10% might subsidise public transport; 3% might reduce employee parking and 3% might pass the costs onto customers.

#### **Conclusion**

The small body of existing evidence suggests that a workplace parking levy could potentially be an effective tool for changing behaviour, but is inevitably controversial. Much would depend upon the extent to which employers absorbed the costs rather than passing them onto their employees.

#### **Quick win**

If the introduction of the WPL looks likely to proceed in Nottingham a Revealed Preference study could usefully identify actual responses by employers and employees.

#### **4.3.10 Stadia**

A match day CPZ (Controlled Parking Zone) was implemented around Watford Football Club in 2000, following the introduction of a town-centre CPZ in 1997<sup>167</sup>. The average gate was 13,000 but the area lacked easy parking since it located in west Watford with mainly terraced housing. Prior to the scheme's introduction four surveys on match days showed that about half of the streets within the area were at least 50% parked and that some were consistently over-capacity. Follow-up surveys showed that nearly  $\frac{3}{4}$  of respondents in the area were satisfied or very satisfied with the SPA scheme;  $\frac{2}{3}$  considered enforcement to be adequate; over  $\frac{3}{4}$  did not want changes to the rules. A review undertaken in 2001 indicated that the scheme has had benefits on wider transportation, environmental and quality-of-life issues.

#### **Conclusion**

Despite their importance as movement generators little independent research has been published into the impact of parking policies at stadia.

<sup>165</sup> Workplace Parking Charges Down Under, M Enoch, Traffic Engineering & Control, 2001

<sup>166</sup> A Comparison of Four Travel Demand Management Measures, T May, F Hodgson, A Jopson, D Milne, M Tight, Traffic Engineering & Control, 2000

<sup>167</sup> Watford Match Day Parking Scheme, Thomas, ICE Transport Proceedings, 2003

### 4.3.11 Airports

#### **Research Question 14**

Does the research show that the parking behaviour at airports of business travellers differs to that of leisure passengers?

Newcastle Airport was the subject of a study<sup>168</sup> into passengers' choice of ground access mode. A Revealed Preference questionnaire was used to maximise responses. A multinomial logit approach used a choice set comprising:

- long-stay parking;
- car drop-off;
- taxi;
- Metro; and
- bus.

The addition of an extra car in a passenger's household was found to increase (6-fold) the odds of using the long-stay car park rather than a bus. Business travellers were found to be more sensitive to access time than leisure travellers. Likewise those travelling to domestic destinations were also more sensitive to access time than those travelling overseas. Passengers earning £20,000pa or more also valued access time more highly. Marginal rates of substitution values were also calculated. Their results showed that mode choice is heavily reliant, not only on access time and access cost, but also on factors such as the number of cars in the household, the size of the group and the amount of luggage.

A review<sup>169</sup> of *Car Parking Management at Airports*, examined four non-airport workplace case studies and compared these with findings from a survey of airport employees on potential reforms to manage capacity at a large UK airport. The non-airport case studies affirmed that senior management support and a fuller appreciation of the problems associated with parking capacity improved the effectiveness of travel plan measures. Survey and focus group results highlighted the complex nature of airports and, in particular, the multi-organisational environment which complicated the establishment of charging mechanisms for individual employees. The identification of who should lead such measures and the pathway for implementation seemed unclear and complex.

An analysis of factors affecting how travellers choose between remote and terminal parking facilities was undertaken by Chaug-Ing Hsu & Fu-Shan Lin<sup>170</sup> using Singapore as an example. A demand distribution model was formulated by assuming that travellers choose the parking facility with the minimum total parking cost with respect to their parking duration and other characteristics. On the basis of this model, a parking duration control model was then formulated to maximize the operator's revenue while maintaining the levels of services and balancing the utilisation of parking facilities. The model showed that parking revenues would be reduced if the operator imposed parking duration control to maintain the level of terminal parking services and increased utilisation of remote parking.

<sup>168</sup> Modelling Surface Access Mode Choice of Air Passengers, Jehanfo and Dissanyake, ICE Proceedings Transport Issue TR2 (May) pp87-952009

<sup>169</sup> Car Parking Management at Airports, K Aldridge, M Carreno, S Ison, T Rye and I Straker, Transport Policy 13(6), 127-135, 2006

<sup>170</sup> Demand Distribution and Operating Strategies of Airport Remote and Terminal Parking Facilities, Chaug-Ing Hsu and Fu-Shan Lin, Transportation Planning and Technology, 1996

This paper introduced the concept of "critical parking duration" to determine the optimal choice and aggregate parking demand on the two types of facility. The approach was simple and could be used to develop a model for parking duration control. The results showed that business and short parking-duration travellers tended to choose the terminal parking while non-business and long duration travellers tended to choose the remote parking. For the same demand level, the remote parking facility should provide more parking spaces than the terminal parking facility, due to longer average parking duration. Reductions in access time and parking fees for a parking facility would stimulate parking demand for this facility.

Finally, in regard to parking duration regulation, parking revenues would be reduced when the terminal parking facility was crowded and the operator applied parking duration control to increase the use of remote parking while maintaining use and service levels of terminal parking. On the other hand, the parking revenues increased when the remote parking facility was overutilised and the operator applied parking duration control to balance usage between these two different parking facilities.

At Heathrow the challenge was to manage the growth of Heathrow businesses within the 42,000 car parking cap when demand was forecast to exceed this supply<sup>171</sup>. In April 2004 there were 34,602 Heathrow controlled spaces and 11,460 tenanted spaces. Annual parking for staff passes cost in the region of £500 – £800 per space depending upon the location of the car park. In most cases the employer pays. Employee car parking is regulated which means that charges are set to cover costs. The overall objective of Heathrow's Car Parking Strategy was to ensure that car parking facilities are used as efficiently as possible by passengers and employees who are not able to take advantage of public transport services or other alternatives to the car.

### **Conclusion**

Those with higher values of time, such as business passengers, tend to park closer to airport terminals; leisure travellers are prepared to park farther away.

## **4.4 Impact of parking**

### **4.4.1 Parking and Congestion**

#### **Research Question 15**

Does the research indicate what the impacts of short stay and long stay parking facilities are on congestion?

Acutt and Dodgson<sup>172</sup> argued that traffic congestion should fall in a parking controlled area unless counterbalanced by increased search activity. However, P&R schemes could increase emissions because they may generate extra car trips as well as ones which are relatively short and therefore suffer from cold start problems.

Surveys in the US cited by Litman<sup>173</sup> indicated that 8-74% of commercial centre traffic congestion was caused by vehicles cruising for an on-street parking space. *Cruising for Parking* (Shoup, 2006) reported that between 1927 and 2001, studies of cruising in congested town centres found that it took between 3.5 and 14 min to find a parking space.

<sup>171</sup> Changing Direction, Heathrow's Travel Plan 2004 – 07, BAA, 2004

<sup>172</sup> Controlling the Environmental Impacts of Transport: Matching Instruments to Objectives, M Acutt and J Dodgson, Transportation Research ex-D, Vol. 2, No. 1, 1997

<sup>173</sup> Parking Pricing Implementation Guidelines, T Litman, Victoria Transport Policy Institute, 2010

A survey<sup>174</sup> of 5,060 commuters to downtown Los Angeles by Shoup and Willson estimated how employer-paid parking affected transportation system performance. They concluded that that employer-paid parking:

- Increased the number of SOV drivers by 44%;
- Increased parking demand by 34%;
- Increased automobile vehicle miles travelled to work by 33%;
- Increased gasoline consumed for driving to work by 33%;
- Increased the cost of automobile travel to work by 33%; and
- Increased the total cost of parking at work and driving to work by 33%.

Charging for parking may be an effective policy. Litman<sup>175</sup> suggested that cost-recovery parking fees (such as 50¢ per hour or \$5.00 per day) typically reduced car travel by 10-30%, comparable to a 5-15¢ per vehicle-mile road toll. Modelling estimated that in Southern California (all values in 1991 dollars):

- A 10¢ per vehicle-mile congestion fee reduces VMT (Vehicle Miles Travelled) 2.3% and congestion delay 22.5% (a 9.8 ratio).
- A \$3.00 per day parking fee would reduce VMT 2.7% and congestion delay 7.5% (a 2.8 ratio).
- A 2¢ per vehicle-mile VMT fee reduces VMT 4.4% and congestion delay 9.0% (a 2.0 ratio).
- A \$0.50 fuel tax increase reduces VMT 4.1% and congestion delay 6.5% (a 1.6 ratio).
- A 1.0¢ per vehicle-mile emission fee reduces VMT 2.2% and congestion delay 3.0% (a 1.4 ratio).

Efficient management is often more cost effective and beneficial overall than expanding parking supply, according to Litman<sup>176</sup> particularly in areas where land is expensive or compact development desired. For example, it was often more cost effective for employers to subsidise alternative modes than to expand employee parking, and for municipal governments to implement a parking management program than to build more downtown parking facilities.

A major research study was undertaken into the impact of dramatically increasing charges for long-stay parking in Bristol<sup>177</sup> using a specially developed model (TRAM – Traffic Restraint Analysis Model). This compared a do-minimum situation with a proposed do-maximum scenario comprising:

- Large fall in supply of PNR parking in central Bristol;
- Large charges applied;
- Increased charges for short stay parking; and
- Enforcement regime changes.

The charges tested aimed to reduce long stay parking by 34% i.e. very high at £30-50 a day. As a result a dramatic fall in parking, both long and short-stay, occurred (see table 14 below).

**Table 14: Parking responses to higher charges and fewer spaces in Bristol**

	Base year		Do maximum	
	Short	Long	Short	Long
<b>PNR in Zone 1</b>	12,420	8,881	2,484	1,776
<b>Public parking demand</b>	14,107	9,946	15,575	5,594

<sup>174</sup> Commuting, Congestion and Pollution: The Employer-Paid Parking Connection, D Shoup and R Willson, University of California, 1992

<sup>175</sup> Parking Pricing Implementation Guidelines, T Litman, Victoria Transport Policy Institute, 2010

<sup>176</sup> Parking Pricing Implementation Guidelines, T Litman, Victoria Transport Policy Institute, 2010

<sup>177</sup> Study of Parking and Traffic Demand: Stage 2 – Effects on Land-use, MVA for DfT, 1996

<b>Public parking &amp; search time (Mins)</b>	8.8	11.9	8.9	11.0
<b>Public parking charge</b>	0.91	3.00	0.91	41.44

In summary the effects were:

- Use of PNR parking fell 80% for short and long stay parking;
- Use of public parking for long stay fell 34%; and
- Use of public parking for short stay increased 33%.

Several research papers cover both road user charging as well as parking charges. Indeed they sometimes appear to be considered as alternatives or complementary. Parking charges may be considered a more acceptable way of charging for road use since it is already commonly applied. However as Bonnafous and Raux<sup>178</sup> point out, paying for parking dissuades people from stopping in areas where charges apply but it does not dissuade them from crossing them while tolls do.

### **Conclusion**

There is a lack of evidence to demonstrate that parking restraint or charging reduces congestion, though there is a logic that they should do so given the evidence that they potentially impact upon car use.

#### **4.4.2 Parking and Congestion Charges**

##### **Research Question 16**

Can parking charges be considered as an alternative to congestion charges?

Several papers related parking, especially charges, to the introduction of road use charging.

Reductions in congestion and parking problems, and increasing environmental quality are probably considered as favourable consequences of the London congestion charge, for example because they improve the general quality of life in cities.

After a trial reported by Schuitema *et al*<sup>179</sup>, respondents believed that congestion, parking problems and pollution decreased more than they believed before the charge was implemented. Respondents to a survey considered it more likely that congestion, parking problems, and pollution had decreased after the implementation of the charge than they had expected beforehand, which suggested that respondents had more favourable beliefs about the charge. Moreover, perceived reductions in parking problems appeared to be relatively more important for acceptance levels of the congestion charge than other positive effects that were perceived (e.g. reductions in congestion and pollution). Apparently, the respondents to Schuitema's survey were more concerned about parking problems than about congestion or pollution levels.

A study<sup>180</sup> undertaken for the Association of London Government in 2004 identified that the number of paid parking acts in the charged area had fallen broadly in line with the reduction in the number of car trips into the charged area. On-street parking acts in the charged area fell by 28% between 2002 and 2003 while off-street parking acts in the

<sup>178</sup> The Funding of Urban Transportation and the Issue of Road Pricing, A Bonnafous and C Raux, International Journal of Transport Economics, 2009

<sup>179</sup> Explaining Differences in Acceptability Before and Acceptance After the Implementation of a Congestion Charge in Stockholm, G Schuitema, L Steg, S Forward, Transportation Research Part A 44, 2010

<sup>180</sup> Monitoring Congestion Charging: Changes in Parking Usage and Revenues, Arup, 2004

Corporation of London area fell by 30%. This study also pointed to increased parking charges in some boroughs between 2002 and 2003 as the congestion charge was introduced. Table 15 below shows that hourly charges were raised in the London Borough of Lambeth and in the City of London, while the cost of a resident's permit generally increased but was reduced for residents of those parts of Lambeth inside the charging zone.

**Table 15: Parking Charges in Central London Boroughs**

Borough	Cost of parking (per hour)		Cost of residents' permits	
	2002	2003	2002	2003
City of Westminster	£1.50 - £4.00	£1.50 - £4.00	£90	£100
Corporation of London	£3.00	£4.00	£150	£220
LB Camden	NS	NS	£86	£90
LB Lambeth	£1.50 - £2.00	£3.00 - £4.00	£60	£50
LB Southwark	£1.20	£1.20	£76	£76
LB Tower Hamlets	NS	NS	NS	£55

A TfL study<sup>181</sup> reported that the average cost of 2 hours of parking in a public off-street car park in Central London was £2.57 per hour, up from £2.40 per hour in the 1999/2000 survey. In Central London, the average charges for parking stays of different durations in public off-street car parks, which are normally charged for, are as shown in table 16 below. This indicated a significant increase in the fees for longer stays but the paper did not report the impact on the demand for parking spaces.

**Table 16: Parking Charges at Central London Public Off-Street Car Parks**

	Charge
Duration, hours	£
2 hours	£5.14
4 hours	£9.48
9 hours	£17.64
12 hours	£20.16

A study in Israel<sup>182</sup> reported that there was high level of demand elasticity: -1.8 for congestion tolls and -1.2 for parking fees. The readiness to pay parking fees is greater, thus, the effectiveness of congestion tolls in reducing demand is higher during the times the tolls apply. This Stated Preference study was conducted in the absence of congestion charging within the country however.

Litman<sup>183</sup> argues that parking pricing can reduce traffic congestion, by reducing traffic caused by motorists cruising for an unoccupied parking space, and by shifting travel to alternative modes, particularly if implemented widely throughout an urban region and in conjunction with other demand management strategies<sup>184</sup>. The actual impacts depended on various factors however: the proportion of parking priced, the magnitude and structure of fees, the extent to which motorists actually pay parking fees, and the quality and price of alternative parking spaces and transport options.

Parking pricing was considered particularly appropriate<sup>185</sup>:

- Where parking facilities are costly, where land is valuable or parking facilities are structured.

<sup>181</sup> Update of London Parking Supply Study, MVA for TfL, 2005

<sup>182</sup> Congestion Tolls and Parking Fees: a Comparison of the Potential Effect on Travel Behaviour, G Albert and D Mahalel, Transport Policy, 2006

<sup>183</sup> Parking Pricing Implementation Guidelines, T Litman, Victoria Transport Policy Institute, 2010

<sup>184</sup> Booz Allen Hamilton, 2006

<sup>185</sup> Parking Pricing Implementation Guidelines, T Litman, Victoria Transport Policy Institute, 2010



- In commercial centres with more than about 5,000 employees, since beyond this size surface car parks cannot satisfy total parking demand, requiring costly structured parking facilities.
- In areas that want to encourage use of alternative modes to reduce traffic congestion, energy consumption or pollution emissions.
- In areas where environmental protection or community livability justify efforts to reduce impervious surface area (the amount of paved land) and total vehicle travel.
- Where development affordability is an objective.
- When property owners or governments need additional revenues.

### **Conclusion**

There appears to be a tendency for higher price elasticities for congestion charges than for parking fees.

#### **4.4.3 Carbon emissions and pollutants**

##### **Research Question 17**

Does the research indicate that parking restraint of charges reduces carbon emissions or pollutants?

Little evidence exists of the impact of parking charges, and policy, upon carbon emissions.

Research cited by Acutt and Dodgson<sup>186</sup> (from Abbott *et al* 1995, p. 37) indicated that experimental Red Route controls on on-street parking on major routes into London increased speeds and reduced emissions of volatile organic compounds and carbon monoxide, though there were much lower reductions in NO<sub>x</sub>.

However Acutt and Dodgson also cited a paper by Dasgupta *et al* (1994) reporting simulation studies of doubling parking charges in five British cities which suggested that they would reduce the car share of central area trips by 13%, from 56% to 43%. Carbon dioxide emissions across the cities would consequently be reduced by around 24%. Citywide reductions in vehicle-kilometres were less than would be achieved by increasing fuel prices by 50% however, but greater than from halving public transport fares. If parking charges reduce traffic levels, they would also reduce carbon dioxide emissions, other emissions (especially in urban areas), noise, accidents and traffic congestion. But because car users might divert their trips to other destinations the overall impact would depend on how widespread the parking charge increases were to be.

One project, unreported to date, that does touch on CO<sub>2</sub> emissions is a TRL project for Islington Borough Council where a CO<sub>2</sub> Calculator has been designed to allow Islington Council to assess the effects of changes in the charging structure of its parking permit scheme on exhaust emissions of CO<sub>2</sub> from the vehicles covered by the scheme. A spreadsheet has been developed to analyse parking permit bands against emissions and social cost; although no definitive conclusions have as yet been made.

Litman<sup>187</sup> argued that the benefits from efficient transport and parking policies tended to be greater in value than energy conservation and emission reduction benefits. For example, \$27 per ton of CO<sub>2</sub> equals about 1.2¢ per vehicle-mile, which is smaller than other vehicle costs such as fuel, road and parking facilities, accident damage, and even local pollution costs. As a result, a unit of energy conserved by reduced driving provides

<sup>186</sup> Controlling the Environmental Impacts of Transport: Matching Instruments to Objectives, M Acutt and J Dodgson, Transportation Research ex-D, Vol.2, No. 1, 1997

<sup>187</sup> Recommendations for Improving LEED Transportation and Parking Credits, T Litman, Victoria Transport Policy Institute, 2008

far greater total benefits to society than the same amount of energy saved through increasing building energy efficiency or shifting to alternative fuels, due to co-benefits such as congestion reduction, consumer savings, reduced traffic accidents and improved public health.

Jane Hall<sup>188</sup> concluded from a literature review that a single TCM (Transport Control Measure) was unlikely to meet the desired goals for congestion and emissions. Hall reported that parking pricing reduced work vehicle miles 0.52-4.01% (trips 0.39-4.02%); non-work 3.10-4.2% (trips 3.9-5.4%) (see table 17 below).

**Table 17: The Impact of Parking Pricing**

Parking pricing	Veh mls travelled	No of trips	
work vehicle miles	0.52-4.01%	0.39-4.02%	
non-work	3.10-4.2%	3.9-5.4%	
Joint impacts	Change in VMT	Change in Trips	Change in Emissions
Parking price	2.6-6.2%	3-5.1%	HC & NOx 1% CO <sub>2</sub> 3%

Hall concluded that TCMs that generate the largest decreases in peak VMT (Vehicle Miles Travelled) and that the number of trips are not associated with the largest emissions reductions – fuel price increases are the most effective. To her *"this suggests that the link between congestion and air quality is not as strong as has been assumed."*

Car Clubs offer the potential to reduce carbon emissions and there is some evidence that these initiatives are effective in reducing emissions. The annual Carplus survey reported that Car Club vehicles only emit 64% of the CO<sub>2</sub> emissions per km travelled<sup>189</sup>.

#### **Conclusion**

Few studies directly reported on the impact of parking upon traffic reductions, congestion, modal shift or contributions to reductions in carbon emissions.

#### **4.4.4 Sustainable transport**

##### **Research Question 18**

Does the research indicate that higher parking charges or restraint leads to greater use of sustainable transport measures?

Interviews undertaken by Mackett and Ahern<sup>190</sup> showed that there was potential for modal shift. Considering only trips shorter than 5 miles, viable alternatives were identified for 78% of car users by investigating public transport and other opportunities. If public transport were improved apparently 21% of drivers could be attracted to use it.

Bus travel involves walking to the bus stop, waiting, the vehicle ride and the walk (ride) to the final destination. Travel time budgets may be longer for public transport users than car drivers and passengers. The waiting time generates a greater disutility than the in-vehicle time<sup>191</sup>. Regular service levels allow passengers to 'turn up and go' while

<sup>188</sup> The Role of Transport Control Measures in Jointly Reducing Congestion and Air Pollution, J Hall, Journal of Transport Economics & Policy, 1995

<sup>189</sup> Carplus Survey, D Myers and S Cairns, TRL, 2009

<sup>190</sup> Potential for Mode Transfer of Short Trips: Report on the Analysis of the Survey Results, R Mackett and A Ahern, UCL for DETR, 2000

<sup>191</sup> The Demand for Public Transport, R Balcombe (Editor), TRL Report 593, 2004

wider headways requires planning for specific departure times. Relatively cheap and easy car parking in many areas disadvantages public transport users. According to *The Demand for Public Transport*, parking controls may be beneficial in encouraging public transport patronage. The review cited research<sup>192</sup> into the impact of the Manchester Metrolink as leading to some 690 long-stay parking acts in the city centre as likely to have been removed and 520 short-stay ones.

### **Conclusion**

More research is needed into the interaction between sustainable transport measures and parking availability.

#### **4.4.5 Business activity and town centre viability**

### **Research Question 19**

How do parking restrictions and pricing mechanisms affect town centre viability?

Information on the impact of parking restrictions and higher parking charges upon local economies, especially shopping, varies.

In a, now fairly old, study of 27 of the largest towns in England<sup>193</sup> a review of the policies implemented by local authorities and an assessment of the impact on traffic, the environment and economic vitality was undertaken. Price increases were being used by authorities to encourage short stay and discourage long stay parking. However the proportion of parking within the ownership or control of local authorities was diminishing. Furthermore the survey stated that there was very little evidence of the traffic effects of increasing on-street controls and that none is available of the effects of price changes or the extensions of on-street controls. Most parking in city centres is PNR is but little data is held by authorities.

Interestingly a paper by Betts<sup>194</sup> investigated the relationship between the retail offer and parking fees in the UK and the Netherlands. This reported that most shoppers parked for 1.5-2hrs. The author developed a Parking Price Indicator - the average weighted cost of 2 hrs parking. He concluded that parking fees are related to the level of service of area. Acceptable parking charges depended on the value added of the area – the level of service. Higher prices can be charged the better the area – the higher the shopping centre rank - for example in large towns where the retail offer is best, with some exceptions. Cheaper parking appeared to be less attractive than more convenience to shoppers.

Businesses, particularly retailers, often object to parking pricing out of fear that it will discourage customers. However, experience cited by Litman<sup>195</sup> indicated that customers will pay for parking in areas with attractive businesses and pedestrian environments. Many of the most successful commercial districts have priced parking, and many commercial centres with abundant unpriced parking are economically unsuccessful. The additional revenues from charging for car parking can finance improvements such as new street furniture, more cleaning and security, and marketing, or reduced local taxes.

A study by the RAC Foundation and the British Retail Federation<sup>196</sup> found conflicts between the objectives of town centre managers looking for commercial regeneration and traffic or transport planners intent on transport solutions. In some cases transport

<sup>192</sup> Metrolink Monitoring study Volume 2 Demand Modelling: Pre and Post Implementation, Oscar Faber for DfT, 1996

<sup>193</sup> The Effect of Parking Policies in England: Stage 1 Final report, Atkins for DfT, 1996

<sup>194</sup> Parking Fees and the Quality of a City Centre, I Betts, Parking Trend International, 2009

<sup>195</sup> Parking Pricing Implementation Guidelines, T Litman, Victoria Transport Policy Institute, 2010

<sup>196</sup> Shopping and Transport Policy, RAC/BRF, 2006

decisions on issues such as one-way streets or restricted parking had dire consequences for the commercial vitality of town centres. Ease of parking was considered crucial to shopping and needed to be seen as a service to shoppers according to this study; apparently the survey showed that 44% of shoppers could not find a parking space whilst out shopping in the previous twelve months. Some 40% found parking too expensive. Steep congestion charges may well drive shoppers to out of town centres; low off-peak charges may mitigate some of these negative effects.

The RAC/BRF study argued that the availability of parking was important for 85% of people buying groceries and 76% of those buying household goods, but is less important for clothes shopping (60%). Even for those in households without a car, parking was considered important because people often get lifts to the shops. When asked what they would do if parking became more expensive or difficult, over half of those surveyed said they would shop somewhere else. Those with no car in their household, who nevertheless use a car to go shopping, responded in a similar way to those in car-owning households.

Insufficient parking provision may reduce the viability of the town centre as a retail trading location. The 2002 Lockwood Survey for Boots, cited by the RAC, assessed 174 centres and compared retail performance with the amount and convenience of parking. The report identified that the quantity of parking available within a five-minute walk of the principal shopping streets had a significant impact on store performance. For medium sized and larger towns the optimum level of parking provision was identified as between 45 and 89 spaces per 1000 sq metres of gross shopping floorspace, and at least 85% of parking should be within five minutes walk of key shopping streets.

An investigation by CB Richard Ellis for the RAC/BRF study, suggested that shoppers were voting with their cars; over 50% of the population reported a preference for clothing/fashion shopping out-of-town because of easier parking and what they considered to be better-stocked shops i.e. the retail offer.

Restricting parking is contentious. People seem to prefer innovations giving them additional chances or choices according to Schlag and Schade<sup>197</sup>. Based on surveys in several European cities, the only restrictive measure which could be designated as being accepted by the majority was some kind of access restriction; 90% in York, although such measures would not be acceptable in Graz (37%). The survey reported that 43.4% found reducing parking space absolutely unacceptable but this was less than increasing parking costs (50.4%); cordon pricing (51.5%); distance based pricing (58.2%); congestion pricing (53.5%); public transport improvements (2%); P&R (2.3%); access restrictions (22.6%); or a package approach comprising both parking restrictions and public transport improvements (32.2%).

Research in Austria, cited by COST<sup>198</sup> indicated that actual behavioural change was much less than originally expressed. The implementation of restrictive parking policies in Vienna, Parkraumbewirtschaftung Wien, since 1993 did not directly affect the structure of the local economy. In the Netherlands a study showed that within 12 months the town's trade recovered to the same level as before any change was introduced. In The Hague a survey aimed at establishing the effects of the closure of a car park found that most users would search for parking in the surrounding area, about 25% would do their shopping elsewhere and 20% would change to using public transport. However in Trondheim, Norway, it was found that removing parking spaces had led to considerable changes in shopping destinations. In another study cited by COST in The Hague the removal of a long-stay car park for commuters revealed that the average walking distance of previous users still driving had increased by one third but that 20% had shifted to other modes.

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<sup>197</sup> Acceptability of Urban Transport Pricing Strategies, B Schlag and J Schade, Transportation Research Transportation Research: Part F: Traffic Psychology and Behaviour, Volume 6, Issue 1, March 2003, Pages 45-61, 2002

<sup>198</sup> Parking Policies and the Effects on Economy and Mobility, COST, 2005

### **Conclusion**

Critics often claim that parking pricing spoils local economic activity by discouraging customers, but it actually provides both economic benefits and costs. It increases turnover of parking spaces which makes finding a space easier, reduces the number of parking spaces required at a location which can provide financial savings, and can reduce traffic problems such as congestion. General levels of provision may affect access modes, in turn, impacting on the quality of the shopping environment.

The precise impact of parking restraint measure upon local economies is difficult to identify.

#### **4.4.1 Urban Design, Landscape and Townscape**

The DfT expressed interest in learning of the impact of parking upon the built and natural environment; urban design, landscape and townscape. While there may be robust research papers available TRL failed to discover any in the journals investigated.

#### **4.4.2 Modelling innovations**

##### **Research Question 19**

Is there a standard modelling approach applied in the research to investigate the impact of parking policies.

No single model has emerged as the preferred choice for parking research. Much economic analysis has used stated preference or similar techniques while hypothetical approaches have also been used, especially by academics

Some studies have developed new models to understand parking behaviour. For example, TRAM – Traffic Restraint Analysis Model was developed for Bristol as part of a much larger project<sup>199</sup>. This allowed a wide range of responses to transport changes. An External Forecasting model (EFM) provided input into transport for both demand and supply sides. The EFM generates the demand matrices. The model uses two land-use change indicators:

- Change of use; and
- Location/ intensity of activities.

The model was used to forecast the impacts of four do-maximum scenarios:

- A large fall in the supply of PNR in central Bristol;
- The application of large parking charges;
- Increased charges for short stay parking applied; and
- Enforcement regime changes.

In Truro an activity-based parking model was developed, linking to a traditional four-stage transport model<sup>200</sup>. Monte Carlo techniques were applied to select individual car parking spaces while choice co-efficients were derived from Stated Preference experiments. The authors claimed that this type of model can be used to test a very wide range of policies e.g. closing/opening car parks, changing the type of car park and charges, and access/ egress arrangements etc. It can also to predict their impact on traveller behaviour.

<sup>199</sup> Study of Parking and Traffic Demand: Stage 2 – Effects on Land-Use, MVA, 1996

<sup>200</sup> Small Sized City case Study: Truro, Cornwall, P Davidson and P Clarke, Traffic Engineering & Control, 2009

### **Conclusion**

It is perhaps surprising that no single model has emerged as the preferred approach in parking research.

#### **4.4.3 Major comprehensive parking studies**

Two large parking studies have been reviewed: Bristol<sup>201</sup> and Hong Kong. Not only were both large they also attempted to address a wide range of parking and related issues.

In 1991 a major research programme was launched into urban congestion in London, its causes and possible cures – partly using experience from Bristol as case study material. Three papers were published in *Traffic Engineering & Control* in 1997 that described the approach:

- Study of Parking and Traffic Demand: The Research Programme, D Coombe, P Guest, J Bates, P Le Masurier and C Maclennan;
- A Traffic Restraint Analysis Model (TRAM), Bates, Skinner, Scholefield and Bradley; and
- The Effects of Parking Control Strategies in Bristol, D Coombe, P Guest, G Scholefield and A Skinner.

Four key issues were investigated:

- The effects of parking controls on travel patterns;
- The effects of parking controls on travel demand;
- The effects of parking controls on traffic congestion; and
- The mechanisms for controlling parking.

The reactions of drivers to controls on parking were identified as:

- Change of parking type;
- Change in location of parking;
- Change of mode of travel;
- Change of car occupancy;
- Change in destination;
- Change in frequency of trip making;
- Change in time of travel;
- Change in parking duration; and
- Change of route.

The TRAM study in Bristol concluded that the most extensive package of measures to control parking would bring about significant reductions in both the numbers of trips and traffic levels in central Bristol. Measures to deter through-traffic from the central area would re-inforce the parking measures and secure further reductions in traffic levels there.

In Hong Kong the study comprised undertaking extensive surveys to establish parking characteristics and a parking inventory. An Stated Preference survey was undertaken to

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<sup>201</sup> Note that Bristol was being used as a case study to inform policy development for London.

estimate the influence of parking space availability on modal choice, development of parking demand models for cars and goods vehicles. Two papers have been published describing the approach, both in ICE Proceedings;

- The Hong Kong Parking Demand Study, W Lam, R Fung, S Wong and C Tong, (1995); and
- The Hong Kong Second Parking Demand Study, W Lau, P Poon, C Tong and S Wong (2005)

The objectives were to:

- Prepare a comprehensive parking inventory;
- Develop a parking demand model;
- Identify districts with existing/ future shortfall in parking facilities;
- Review the Hong Kong standards and guidelines; relating to parking provision;
- Recommend solutions to problems identified by the study; and
- Demonstrate how the recommendations could be recommended.

Demand models were developed to predict the future day and night-time parking demand over a planning horizon of 15 years. Three types of measure were identified:

- Measures to be implemented through the planning process;
- Measures to be implemented through management; and
- Measures to be implemented by using advanced technology.

## 5. Discussion

Relatively few research papers directly address all the issues in which DfT are interested. Particular gaps arise in evaluation studies, linking parking to congestion, CO<sub>2</sub> emissions and sustainable transport. The impact of parking provision upon the urban environment and streetscape has barely been considered in the papers and report reviewed. While some studies investigate the impact of parking controls on traffic, this is usually only indirectly concerned with congestion and carbon emissions; traffic levels can be viewed as a surrogate for these variables. As a basis for the policies outlined in DaSTS, the findings as a whole do not provide as clear and unequivocal evidence demonstrating the impacts of different parking policies. Nevertheless several papers report very interesting results or interpretations that would contribute to the policy debate and help to determine research priorities. This report has helped to build the evidence base for further investigations and policy development.

Levels of parking charges appear to be relatively arbitrary: parking charges do not necessarily reflect the cost of provision, especially of multi-storey car parks; whilst, at the same time, they do not reflect the market price and what users would be prepared to pay. Parking is expensive to provide in new developments, but the basis for these costs is not commonly researched.

Some papers report parking costs, sometimes in locational studies, but these may not now be appropriate due to inflation and the time since the study was undertaken. One issue is that whereas charging for parking is traditionally a step-function, with prices increasing incrementally at infrequent intervals, parking demand is a continuous function, having experienced steady growth over recent years. As a result parking charges tend to lag behind increases in demand so pressure is continuously placed upon the highway network. In this way parking pricing policies, in isolation from other interventions, may not be an effective management measure.

Many studies are concerned with the application of market measures to manage parking, especially in urban centres. Evidence of price elasticities is available but these will be subject to a variety of influences, not only absolute and relative prices: availability of alternative parking; public transport provision; real incomes; charging boundaries; trip purposes etc. These will vary between locations so the elasticities for one location may not be replicated elsewhere. Travel behaviour depends on a wide range of psychological, sociological as well as economic issues which also need to be understood; and in particular driver behaviour.

Few robust evaluation studies have been identified in our research so the impacts of different parking policies upon the key indicators of interest to the DfT have been difficult to discern. This is a general failing – when new parking policies are implemented they should be independently evaluated and the lessons learnt, particularly their contribution to reducing carbon emissions and congestion. Often short term effects are considered but the longer term effects of parking policy have not received as much attention which are also intertwined with driver behaviour and social acceptability of policy measures.

While interesting in themselves papers that cover overseas experience may not be directly replicable in the UK. Thus their results should be treated with caution. However these papers often report the most recent research and, despite covering societies with different approaches to the subject, provide a useful insight into the issues.

The methodologies applied in the studies vary; many studies use surveys. The use of scenarios is also a feature particularly with regard to road pricing policy in which parking pricing is often a subset. Others use various models but no standard modelling approach has emerged. Delphi techniques have also been applied.

The research reviewed has applied a range of different techniques. Most common have been Stated Preference surveys directly asking people about their preferences regarding, for example, parking charge increases. However some have been conducted on relatively small samples. Doubts must exist about the actual behaviour of respondents



in real world situations when such issues are considered within the context set by various transport, and non-transport, factors. Parking charges may represent only a relatively small element of a journey's cost and, since much parking is available for free, drivers' responses may be more complex than studies suggest. Furthermore studies tend to be at a single point in time without considering how behaviour changes. Good Stated Preference surveys can, however, provide a useful indication of the type of response to be expected and an indication of which policies are likely to be effective at managing parking.

A particular failing appears to be the lack of reliable parking information. The stock of PNR parking, one of the key influences on driver behaviour, is generally unknown with surveys only covering part of the provision. This is an issue that needs to be addressed. Likewise the level of on-street and residential off-street parking is also uncertain. These data gaps, which would be very difficult, and costly, to rectify across the whole of the UK, nevertheless impede analysis and hence policy making.

While TRL operates an annual Parking Benchmarking Initiative that collects and tabulates data relating to member local authority's parking operations there is no evidence that it is applied as a standard for data collection by all local authorities. As a result comparative studies may be difficult. There may also be a need to update the London Parking supply database.

Parking management is defined as the strategic application, and use, of existing and planned parking spaces, both on-street and off-street, in a given area. Parking management is a system management tool which addresses how vehicles access, use (length of time) and egress from parking spaces. These tools include the:

- Designation of long term and short term parking.
- Charging strategies.
- Payment technologies.
- Application of Intelligent Transportation Systems (ITS) technologies in facilities that optimise use within a limited area.
- Implementation of parking demand management strategies to encourage multiple use of parking facilities.

Implementation of parking management strategies includes parking demand, supply, pricing, safety issues and location issues. It needs to consider economic and financial feasibility issues, site characteristics, locational features and compatibility with surrounding uses as well as market and regional issues.

As long as parking policy is viewed independent of transportation policy, and as long as on-street and off-street parking are treated independently, there will be a dysfunction. Frequently, this manifests in excess car trips, shortages of on-street parking, an excess of empty off-street parking spaces and degradation of public transport services and of the pedestrian environment. Failure to develop coherent policy is a missed opportunity for achieving transportation objectives. Barter<sup>202</sup> further supported this advocating that regular parking supply and mispricing appears to be the norm across the world.

There appears to be a distinction: parking charges do not necessarily reflect the cost of provision, especially of multi-storey car parks; while parking charges do not reflect the market price and what users would be prepared to pay. Parking is expensive to provide in new developments, but the basis for these costs is not commonly researched.

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<sup>202</sup> Off-Street Parking Policy without Parking Requirements: A Need for Market Fostering and Regulation, P Barter (2010)

## 6. Conclusion

### 6.1 A Paradigm shift

In the UK, and now increasingly in North America, parking planning has undergone a *paradigm shift*, a fundamental change in how a problem is perceived and solutions evaluated. The old paradigm assumed that parking should be abundant and free at most destinations. The aim was to maximise supply and minimize price<sup>203</sup>.

The old paradigm assumed that parking spaces should almost never fill, that parking facility costs should be incorporated into the costs of buildings or be subsidised by local government, and that every destination should satisfy its own parking needs.

The new paradigm strives to use parking facilities efficiently. It considers full car parks to be acceptable and that any spillover problems, such as congestion or carbon emissions, be addressed. It emphasises the sharing of parking facilities between different destinations. It favours charging parking costs directly to users, and providing financial rewards to people who reduce their parking demand. The new paradigm strives to provide *optimal* parking supply and price accordingly. It considers too much supply as harmful as too little, and prices that are too low as harmful as those that are too high.

It is also evident that conventional parking practice is still widely used within suburban areas propagating low density development and urban sprawl<sup>204</sup>.

The new paradigm recognizes that transport and land-use conditions evolve so parking planning practices need frequent adjustment. It allows new approaches to be tried until their effectiveness (or lack thereof) is proven.

The old paradigm results in *predict and provide* planning, in which past trends are extrapolated to predict future demand, which planners then try to satisfy. This often creates a self-fulfilling prophecy, since abundant parking supply tends to increase vehicle use and urban sprawl, causing parking demand and parking supply to increase further.

Booz Allen Hamilton<sup>205</sup> argued that there are therefore two basic roles for parking policy:

- To determine the way in which parking management is used to meet specific parking system objectives (e.g. balancing supply and demand, revenues to cover costs etc); and,
- To determine the way in which parking management is used to meet other policy area objectives (e.g. traffic management goals, accessibility for business and shoppers etc).

Increasingly parking policy is considered to be a subset of transport policy to achieve transport-related objectives. However, parking policy can also be used to promote objectives in other areas (e.g. economic goals by providing sufficient car parking for new developments), and consequently there are often conflicting perspectives on parking policy.

The main conflict facing policy makers has been the conflict between using parking as a means of enhancing car accessibility, or, as a means of selectively controlling car accessibility (and thereby car use).

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<sup>203</sup> Parking Management: Strategies, Evaluation and Planning, T Litman, Victoria Transport Policy Institute, 2008

<sup>204</sup> Off-street parking policy without parking requirements: a need for market fostering and regulation, P Barter, Unpublished, 2010

<sup>205</sup> International Approaches to Tackling Transport Congestion: Paper 2 (Final): Parking Restraint Measures, Booz Allen Hamilton, Victorian Competition and Efficiency Commission, 2006

## 6.2 Research Gaps

There appears to be several gaps in the research: much research was undertaken some time ago and may not be relevant to the current situation; much research is narrow in its focus; travel and parking behaviour has changed since the research was undertaken; new developments will have influenced local travel behaviour; changes in controlled on-street parking will also have affected behaviour; while data may now be inaccurate. As a result, the robustness or replicability of the results of much research should be questioned.

Nevertheless we are able to identify some information gaps in which the DfT could usefully commission new research. The table below highlights both the research conclusions with recommended research.

**Table: Summary of research conclusions and research requirements**

Research conclusion	Recommended research
Research on parking standards is limited – and surveys which ask people about the flexibility of their current behaviour will potentially produce very different results to those which look at longer term trends, or revealed behaviour based on where people are living.	Undertake some research with local authorities to consider before and after effects of larger scale new developments to determine whether parking standards implemented and alternative mobility measures have influenced travel patterns
Travel plans could be used to help mainstream the car-free concept within the UK making it more attractive to both developers and potential residents with benefits in terms of reduced parking needs. Currently, in car free developments, it seems that improvements in other modes of transport and the provision of green space have not always reached the levels which are seen as necessary to make such developments successful.	Research might investigate the changes to other modes of transport that have accompanied the development of car-free settlements.
Little research exists on the effectiveness of types of demand management measures in residential areas, particularly with regard to longer term impacts. Car Clubs potentially offer an exciting new opportunity to reduce car ownership in densely populated areas.	More assessment of the impacts of CPZs and RPZs in relation to the prices that people are willing to pay, and the way that such policy initiatives impinge on car ownership would be beneficial.
The availability of parking at destinations appears to be an important factor affecting car use and longer-term decisions about land use. There is some evidence suggesting that high levels of provision can lead to an inappropriate use of valuable land and contribute to car dependency.	
Much research has demonstrated the importance of parking costs to travel choices although the extent of the impact may vary. A combination of parking charges and reducing or restricting parking availability is likely to be most effective in encouraging behavioural change.	
Research on pricing mechanisms asserts that the parking fees do not reflect the full externalities of car usage. Elasticity ranges vary greatly – time, location etc - and therefore must be interpreted within the context they are reported. However they do provide an insight into the social and political acceptability of a range of parking policy measures. Information on long-run elasticities is lacking as few time-series analyses have been undertaken; this is important since parking charges probably lag behind rises in income. Further research is needed into the cross-price elasticities of parking demand with respect to public transport improvements.	<p>An investigation of the responsiveness of parking demand using time series analysis could be undertaken. Further research should be undertaken into the responsiveness of parking demand to public transport fares and service levels as well as incomes. An econometric study could investigate the impact of parking behaviour in response to income and parking charge changes over time.</p> <p>Given the range of figures cited by the various studies quoted, a meta-analysis of the available research that have calculated price elasticities could be undertaken to generate a better estimate of the values in the UK.</p>
Controlled parking zones in city centres are a potentially important policy measure, although problems of	An analysis of several towns or cities with CPZs could be carried out, looking at issues such as

enforcement arise, together with the potentially undermining factor of PNR parking. Data on PNR parking is non-existent or, at best, incomplete.	enforcement, and the role and levels of PNR parking, within the context of an understanding of how the places' strategies have evolved over time.
Much research has been undertaken into the impact of P&R. But while P&R is a popular policy the research evidence identifying its benefits appears unclear: while it may extract traffic from town centres it may also encourage longer car journeys to access the facility. Much will depend on the circumstances in which it is introduced.	A practical trial of a link-and-ride scheme, together with an evaluation of its impacts, could form a useful addition to the knowledge base.
Interchange penalties are an important deterrent to rail travel and combined with the waiting time may discourage public transport use. Parking is therefore potentially needed at railway stations as well as at appropriate drop off areas for "kiss and ride" commuters. However, parking provision may also encourage undesirable behaviour, such as extracting demand from other stations, creating congestion around stations, undermining pedestrian and cycle access and using land otherwise available for sustainable development. Hence, this is a complex issue, worthy of further research.	It might be useful to develop a typology of different types of stations, and different types of locations, in order to identify the levels of parking which could be appropriate in different situations.
Research suggests that it is not just parking charges that influence shoppers' behaviour.	
Research demonstrates that the provision of, usually free, PNR parking spaces is very important in determining travel behaviour for commuting.	
Workplace parking regulation, pricing and cash-out schemes are also likely to influence commuters' travel choices.	A Revealed Preference of sites, in different types of area, where a cash-out option has been implemented could identify their effectiveness in reducing commuter car use.
The small body of existing evidence suggests that a workplace parking levy could potentially be an effective tool for changing behaviour, but is inevitably controversial. Much would depend upon the extent to which employers absorbed the costs rather than passing them onto their employees.	If the introduction of the WPL looks likely to proceed in Nottingham a Revealed Preference study could usefully identify actual responses by employers and employees.
Despite their importance as movement generators, little independent research has been published into the impact of parking policies at stadia.	
Those with higher values of time, such as business passengers, tend to park closer to airport terminals; leisure travellers are prepared to park farther away.	
There is a lack of evidence to demonstrate that parking restraint or charging reduces congestion, though there is a logic that they should do so given the evidence that they potentially impact upon car use.	
There appears to be a tendency for higher price elasticities for congestion charges than for parking fees.	
Few studies directly reported on the impact of parking upon traffic reductions, congestion, modal shift or contributions to reductions in carbon emissions.	
More research is needed into the interaction between sustainable transport measures and parking availability.	
Critics often claim that parking pricing spoils local economic activity by discouraging customers, but it actually provides both economic benefits and costs. It increases turnover of parking spaces which makes finding a space easier, reduces the number of parking spaces required at a location which can provide financial savings, and can reduce traffic problems such as congestion. General levels of provision may affect access modes, in	

turn, impacting on the quality of the shopping environment. The precise impact of parking restraint measure upon local economies is difficult to identify.	
It is perhaps surprising that no single model has emerged as the preferred approach in parking research.	
Surprisingly few major studies focussing on the impact of parking measures appear to have been undertaken within the UK.	

Particular research priorities for the short term are highlighted below:

- Investigation of time series analysis of price elasticities of parking charges, and cross-price elasticities with respect to public transport use, and compare these to cross-sectional data, perhaps using a Revealed Preference approach. The aim would be to discover how elasticities vary between different situations and in association with a range of different policy initiatives;
- Survey work with local authorities to determine how parking policy is being adopted into new developments in conjunction with residential travel plans and alternative mobility measures, such as priority bus access, car clubs, and provision for non-motorised transport. The aim would be to understand how focusing on alternatives to mainstream car ownership can influence car ownership and use;
- A study of the parking regimes applied in different areas and their impacts on car ownership levels. The aim would be to better understand the role that parking policies have on aspirations for car ownership and use;
- A study of the impact of car-free settlements upon car ownership and parking behaviour. The aim would be to understand the extent to which car-free settlements actually impact on car-use; and
- A study of the relationship between the provision of car parking at railway stations and the impact on travel patterns. The aim would be to understand the types of stations where greater parking availability should be provided and the circumstances in which it might be reduced.

Such studies would help to develop the evidence base and inform future policy development.

## Appendix A

<b>Title of Paper</b>	<b>Author</b>	<b>Publication</b>	<b>Year</b>
A Review of Canterbury P and R Scheme	Roberts, A. Parker, T. and Phillips, A.	ICE Transport Proceedings Feb	1998
LUTI Modelling in the Netherlands: Experiences with TIGRIS and a Framework for a New LUTI Model	Schoemakers, A. and Van der Hoorn, T.	EJTIR	2004
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