Batty P, Palacin R, Gonzalez-Gil A. Challenges and opportunities in developing urban modal shift. *Travel Behaviour and Society* 2015, **2**(2), 109-123.

Title: Challenges and opportunities in developing urban modal shift

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Abstract

Continued urbanisation, and the resultant increase in urban trips, presents one of the greatest challenges to the environmental, economic and social sustainability of society. Given that the modal split between transport modes has remained relatively unaltered in recent decades, this suggests that the levels of private car usage will lead to even greater levels of congestion and air pollution in urban areas. Therefore, a modal shift from private to public transport needs to be effected with urgency. However, whilst in theory this could be achieved with relative ease, numerous societal, political and economic barriers have thus far prevented such a shift from occurring. These have been analysed in detail, using a holistic approach which simultaneously considers all stakeholder needs. Recognising that traveller opinions and requirements are fundamental in effecting modal shift measures, the effects of public transport quality attributes on encouraging modal shift are discussed, accompanied by an updated version of the UK Department for Transport's hierarchy of public transport needs. This investigation then proceeds to analyse the effectiveness of methods to control urban car usage, before discussing solutions to address the barriers to a notable, successful modal shift, including guidance on how to design modal shift programmes. This paper provides useful and insightful guidance for all those involved in attempting to evoke sustainable mobility through a modal shift to public transport systems.

1. Introduction

The transport sector accounts for approximately 27% of the energy consumption and CO_2 emissions produced globally, and approximately one third in the European Union (OECD, 2010; IEA & UIC, 2013; IPCC, 2014). Of this, urban transport is responsible for 25-40% depending on geographical location, a figure that is expected to become even greater as levels of urbanisation and motorisation increase (OECD, 2010; EC, 2011). It is expected that by 2025 the global urban population will increase by 40% to 4.5 billion, resulting in a 50% increase in urban trips, with respect to 2005 (UN, 2007; UN, 2008). Transport is a major source of urban air and noise pollution, and is often a major constraint on the quality of urban life (EAC, 2010; Banister and Thurstain-Goodwin, 2011; UN, 2013a). These negative externalities are worsened by congestion, which increases travel times and has a detrimental economic effect (EC, 2011). If the modal split between transport modes is left unaddressed, such problems will be further exacerbated, necessitating a substantial step-change in how urban transport is managed. While curbing mobility would reduce its impact, many parties are understandably opposed to this given its strong historic link to economic growth. Transport has significant and long-lasting economic, social and environmental impacts, and is thus an important dimension of future sustainability (EC, 2011; Haghshenas and Vaziri, 2012).

This demonstrates the need for two areas of focus for urban areas: firstly, to develop their transport system into a seamless, accessible, high-capacity, zero emissions model of sustainable urban transport and secondly, to promote a modal shift from private to public transport (PT), especially high-capacity transport modes. The benefits of modal shift are wide ranging; for example, it would help adhere to the increasingly stringent legislation at national and international level necessitating emissions reduction and air quality improvements (EC, 2008a; EC, 2009a; EC, 2009b; EC, 2011). Several European countries have failed to cut excessive levels of air pollutants in urban areas, which has already resulted in the European Commission (EC) launching legal proceedings against the Government of the United Kingdom – one of the offending countries (EC, 2014). The increase in PT usage over private car usage would also help facilitate societal benefits, resulting in an increase in physical activity and a reduction in congestion levels, traffic accidents and trip times (Rissel *et al.*, 2012; Litman, 2013). The effects of stress brought on by congestion during commuting has been noted to spill over into the workplace, leading to increased absenteeism, reduced job satisfaction and decreased task motivation, effects which are exaggerated by congestion (Wener and Evans, 2011).

Therefore, this paper aims to appraise common methods to achieve these goals from a global, system-level perspective. In order to achieve sustainable, long-term urban transport solutions, such an approach must be used, and should consider land use, transport planning, funding mechanisms and social, environmental and political requirements (Friman *et al.*, 2011). However, before discussing strategies to encourage travellers to change from private to public transport modes, it is worthwhile to provide a brief background on the underlying reasons why specific modes of transport are chosen, which is presented in section 2.

Figure 1 describes the subsequent route this paper will take in understanding how to better effect notable, successful modal shift. It is generally accepted that both ‘pull’ and ‘push’ mechanisms are required to achieve this: ‘Pull’ mechanisms involve providing an attractive, accessible, affordable PT system that meets the needs of the travelling public, whilst ‘Push’ mechanisms aim to break private

car use habits. Both will be analysed in detail in section 3, with a particular focus on understanding how passengers rank individual public transport qualities, to allow for a better focus of investment.

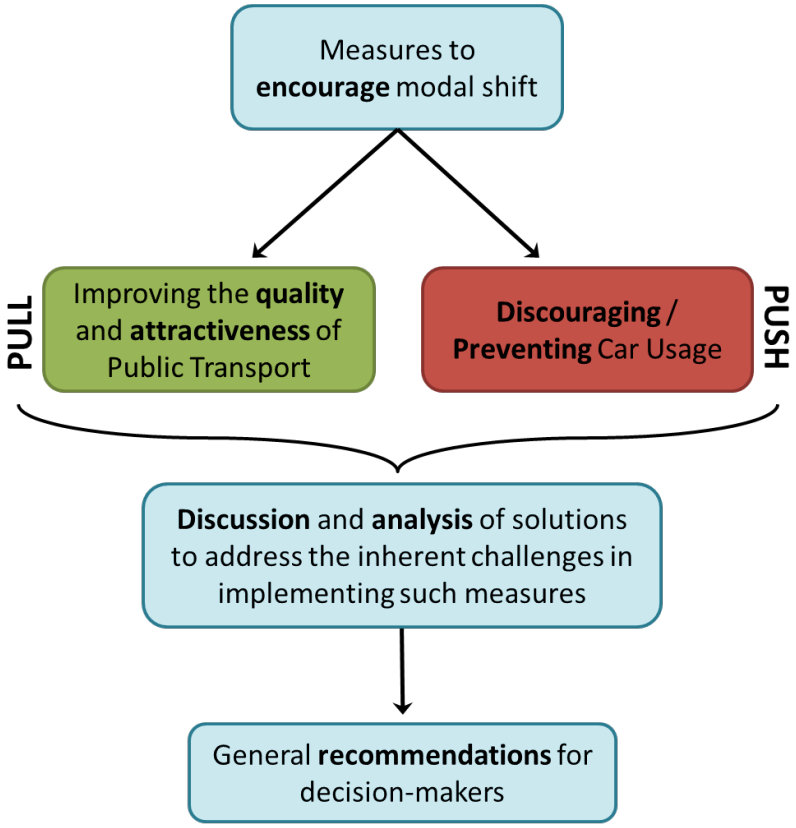

Figure 1: Methodology used by this paper

However, encouraging private car users to use PT for a greater proportion of their journeys has historically been difficult to achieve to any meaningful degree. This is especially the case in urban areas, where a number of challenges stand in the way of success, in particular towards the success of 'push' mechanisms. These include technological, cultural and regulatory factors, insufficient/badly-designed programmes to effect modal shift, and the fragmented information currently available to transport policy makers, operators and other relevant organisations (Farla *et al.*, 2010). As such, section 4 will describe and analyse several methods to overcome such barriers, with reference to both case studies and studies from academic literature.

All involved stakeholders should be aware of the successes and failures experienced in attempts to encourage modal shift, although it transpires that, thus far, many are not. Therefore, through the identification of good practices and amalgamation of information from numerous sources discussed throughout this paper, a series of recommendations for PT stakeholders will be developed in section 5. They will provide insightful guidance on how modal shift should best be effected, allowing transport policies and funding mechanisms to be appropriately focussed to ensure maximum impact.

2. Modal choice

The use of private cars is an integral part of the life of many citizens, with many considering the convenience, flexibility and personal space afforded by private cars to be of significant importance (Vredin Johansson *et al.*, 2006; Beirão and Sarsfield Cabral, 2007; Graham, 2010). Therefore, in

addition to its perceived advantage as a symbol of status in society, it can often be difficult to instigate modal shift to PT, with many people being strongly resistant to attempts to effect this (Tertoolen *et al.*, 1998; Thøgersen, 2009). Such habits and mobility routines play an important role in travellers' modal choice, which is strongly influenced by their socioeconomic background, values and perceptions about different transport modes (Lesteven, 2014; Skalska *et al.*, 2014). Indeed, research by Lesteven (2014) suggests that the resistance to changing from private transport modes is such that a certain proportion of private car users continue to use their car, even when the congestion levels are of obvious detriment to their journey.

Research published in 2011 by the DfT found that 65% of interviewees claimed they were willing to change their behaviours to help address environmental issues, although only 42% claimed they were willing to do this by engaging in modal shift to PT (Department for Transport (UK), 2011). Furthermore, since the start of the recession in the UK in 2008 the negativity of these attitudes has increased significantly, suggesting pro-environmental behaviours are often only considered when people's lives are economically stable. However, recent travel behaviour research suggests that the dynamism in modal choice is higher than expected, presenting an opportunity for policy makers and PT operators to influence mobility behaviour (Skalska *et al.*, 2014). Therefore, developing a greater understanding of what makes PT attractive/unattractive is an important part of improving PT quality and producing successful policies to encourage modal shift.

Multiple modes are necessary to provide an integrated, accessible and inclusive PT system, but at the core of this system must be a high-capacity, high efficiency mode. The two most common modes – BRT and urban rail – are now compared.

BRTs are most popular in cities with a high urban density and low car ownership, such as Latin American and Asian cities (Hensher and Li, 2012). They are usually more easily implemented than urban rail systems, and are commonly the most appropriate/cost effective solution for smaller cities (Tirachini *et al.*, 2010). It is easier to add stations to a BRT system than it is for an urban rail system, in terms of the lower cost and design constraints, although reducing the distance between stations will intrinsically lower the speed of the trip, despite increasing accessibility (Hensher and Li, 2012). It is accepted that there is a social stigma attached to the low-income status of bus patrons, which dissuades many citizens from using it as a transport mode, although this may not be the case in some higher quality BRT systems (UN, 2013b).

By contrast, citizens have been found to exhibit a much more favourable opinion of travel by rail. This is exemplified in the work of Ben-Akiva and Morikawa (2002), who observed a notable preference for travel using a metro system over bus and BRT systems. They further highlighted that travellers reluctant to use buses may use urban rail systems, since they offer a perceived higher quality of service. Furthermore, (Rojo *et al.*, 2012) found that citizens are much more willing to pay a premium for a quick and frequent rail service than for other urban transport modes, including bus and private car travel. In a study of 811 Stockholm commuters, it was found that, with regard to comfort issues, the bus was preferred to the car, while the train was preferred to the bus, with those questioned stating they enjoyed the ability to rest, work and move around (Vredin Johansson *et al.*, 2006). This preference for rail over buses has also been observed by Lee and Senior (2013). Such perceived benefits of rail can have notable positive effects; Cao (2013) found that the light rail system within the Minneapolis-St Paul 'Twin Cities' region had a direct impact on travel satisfaction

and satisfaction with life, in a way that bus services did not. Other benefits exhibited by urban rail include the high quality and visibility of stations, the ability to reduce congestion levels, the lack of local pollutants, the more efficient use of land, the high energy efficiency per passenger-kilometre, and the lower maintenance and operation costs in comparison to similar-sized BRT systems (Cao, 2013).

To summarise, first and foremost, it is vital that efforts should be made to encourage trips in urban areas to be made using public, rather than private transport. Where possible, high-capacity forms of public transport should be promoted, such as BRT and urban rail systems. Therefore, the aforementioned public preference for rail over bus should be considered when attempting to encourage such a behavioural change.

3. Analysis of methods to effect modal shift

Measures to encourage a modal shift to PT can be broadly separated into two main categories – 'Pull' measures, which persuade the user to use PT, and 'Push' measures which dissuade the traveller from using a private car. Section 3.1 analyses 'Pull' measures, focussing on the effects of individual PT quality attributes on ridership levels, whilst section 3.2 concentrates on 'Push' measures.

3.1 Pull Measures

Traveller preferences for PT system qualities play an important role in the ability to attract passengers, and hence to effect modal shift. Therefore, understanding how the quality of the urban PT service affects ridership is vital (Tirachini *et al.*, 2013). Numerous studies have been undertaken globally to understand how individual characteristics affect passenger satisfaction with PT services. However, often it is an amalgamation of characteristics which affect a citizen's choice of transport mode. Therefore, this section outlines the effects of individual characteristics, before assessing five studies that have ranked PT quality characteristics. The findings from this assessment are then used to develop a new hierarchical pyramid of PT quality requirements. While the focus of this paper is upon a transport system with a high capacity core, it nevertheless considers various PT modes in this section, acknowledging that a complete PT system cannot be provided by just one type of PT mode.

3.1.1 Effects of individual quality attributes for urban public transport systems

3.1.1.1 Cost

The pricing of PT, and the effect it can have on making that PT mode a viable option is a complex subject; a balance needs to be struck between the affordability of the PT system (to ensure it remains inclusive) and the needs of the operators to balance their budgets. This can involve lowering, or completely removing the PT fare. Lowering the fare has been suggested as an option to improve the perceived quality of the PT service, although Paulley *et al.* (2006) suggest that the elasticity of such a measure is relatively low.

It is widely accepted that introducing fare-free PT can lead to significant increases in ridership. However, this is not a panacea; such an undertaking leads to a significant loss in revenue, may not encourage a significantly large amount of private car users to change PT modes and makes it difficult to manage demand and overcrowding during peak times. Various instances of free PT have been

introduced, with some focussed upon a certain demographic (i.e. students, the elderly) and others offering free PT usage for all. For example, De Witte *et al.* (2006) records how 'almost free' PT passes were provided to the students of Flemish-speaking universities and colleges in Brussels, who had to pay €10 for a €200 annual PT ticket. Almost half of the eligible students applied for a ticket, which resulted in 26% of participants using PT for journeys previously made by foot or bike.

To encourage greater transport usage and modal shift, the local authority (LA) of the Hasselt municipality in Belgium abolished PT fares in 1996 for all of its 68,000 residents. This resulted in a 428% increase in the usage of the bus services within the first year alone, and a 1319% increase by 2006 (EC, 2013a). The introduction of this no-fare policy was preceded by a significant improvement in the bus services in the Hasselt municipality, although many services still suffered from capacity problems (van Goeverden *et al.*, 2006). This caused the PT operator increasing the invoice to the LA by over 55%, resulting in free PT being limited to those under the age of 19 (EC, 2013a). Therefore, although the free PT policy in Hasselt achieved its main aims of significantly increasing the PT usage within the metropolitan area, this did not lead to long-term sustainable mobility; the scheme necessitated an unsustainable level of PT subsidy, and encouraged journeys that were previously made using non-motorised transport modes (i.e. walking and biking) to be made using PT. Furthermore, given that Hasselt is a small city, extrapolating from the success it has achieved to larger, higher-density cities could prove difficult.

Problematically, while increasing PT affordability and accessibility reduces social exclusion, it can lead more people of a lower social class using the system, which can dissuade existing and other potential passengers from using PT (UN, 2013b). Perone and Volinski (2003) highlight how fare-free PT in Austin (USA) was removed at the request of existing users for this reason. The transport administrators also failed to anticipate the level of the increase in PT usage, which caused significant overcrowding and required an additional $1.5m to be spent on emergency frequency improvements through the deployment of additional bus services.

Modal shift programmes that remove/heavily discount fares on a temporary basis have helped notably increase PT ridership amongst non-occasional public transport users, although when the ticket returns to a normal price the patronage most commonly decreases correspondingly (e.g. Thøgersen (2009); Beale and Bonsall (2007); (Fujii and Kitamura, 2003)). In the case of Thøgersen (2009), the combination of customised timetables and/or planning activities with a free PT ticket proved more successful in encouraging modal shift, although after the free ticket expired, the PT usage still regressed to almost the same level prior to the programme's implementation. The design of modal shift schemes is discussed further in section 4.5.

Therefore, this insinuates that it is possible to develop short-term changes to the modal split, but it will be the quality of other aspects of the PT service that will convince travellers to continue to use the system; indeed, passengers have even been noted to accept a fare increase where the quality has visibly improved (Redman *et al.*, 2013). Therefore, rather than reducing/removing fares, operators are more likely to achieve greater passenger satisfaction and ridership by improving the quality of the service to a level which meets the customers' perceived value of the existing fare price (Hensher *et al.*, 2003). This backs the argument of (De Witte *et al.*, 2006) who states that it would be more pragmatic to invest in improving the quality of the service, rather than increasing the level of PT subsidies. Furthermore, research has also shown that free PT tickets could, in a small amount of

cases, even be considered a bribe or a waste of resources, causing them to use PT even less (Beale and Bonsall, 2007).

3.1.1.2 Safety and Security

Public Transport is significantly safer than travel by private car; (Litman, 2012) states that PT passengers have one tenth of the fatality rates of car occupants. However, it is arguable as to whether safety and security is a quality attribute of PT, since it is likely that many citizens simply intrinsically expect their transport mode to be safe and secure, and so do not feel the need to quantify this requirement when they are asked about it (Vredin Johansson *et al.*, 2006). Nevertheless, UK-based studies suggest that 10% of the population would reconsider PT as a viable option for travelling if their safety and security concerns were addressed (Delbosc and Currie, 2012). To help achieve this, such solutions as CCTV, improved lighting and panic buttons could be installed in waiting areas. However, perceptions of personal safety and safety itself are two important, but very different, characteristics (Delbosc and Currie, 2012). It is important to ensure passengers feel sufficiently secure to access the PT system, which may necessitate improving security at a community level (Aditjandra, 2013).

3.1.1.3 Comfort

Comfort can relate to a variety of PT aspects, such as the ambient air temperature, the availability and quality of seating, the cleanliness of the system, facilities in waiting areas and WiFi provision. It is accepted that factors such as these can change travel from a derived demand into a valued activity, making it a more enjoyable experience than travelling via private car. Such improvements can have a significant effect on ridership; (Foote, 2004) reports that comfort, cleanliness and safety improvements to the Chicago metro led to a 5% increase in the number of trips made over a 5-year period (15 million additional journeys per year), after a sustained period of decline. The provision of free high-speed WiFi on stations and greater wireless connectivity and phone signal in tunnels are becoming common methods of improving the quality of the passenger journey, allowing passengers to undergo enjoyable/useful activities whilst in transit, including accessing up-to-date PT information (Gripsrud and Hjorthol, 2012). However, while such improvements are hugely beneficial and often vital, they require significant levels of investment, which may often not be available. This is discussed further in section 4.4.

Such improvements to the system should always be viewed from a holistic perspective; a higher quality service will likely result in an increased patronage, and consequently a greater number of passengers per square metre. This intrinsically decreases comfort levels, potentially leading to increased stress levels of passengers. However, Japanese commuters consider the stress from crowding to be mitigated by the reliability and punctuality of the service (Cox *et al.*, 2006). Therefore, the comfort levels of PT systems, both in terms of waiting areas and on board vehicles, can be considered of great importance, both in terms of in-trip satisfaction, and for the image that it projects. Furthermore, the EC-funded project AD-PERSONAM, which aimed to encourage public transport usage in medium-sized cities, recommends that any specific schemes to encourage non-/occasional PT users to use PT more should be undertaken in the summer months when the weather is likely to be better, and hence the PT journey more comfortable (AD PERSONAM, 2010). It found that if a non-/occasional PT user experienced bad weather when using PT, they were more unlikely

to continue to try PT in the future. Guidelines regarding good practices for the design and execution of modal shift schemes are further discussed in section 4.5.

3.1.1.4 Information

The provision of sufficient travel information is key to enabling a high ridership. This information can consist of pre-trip travel information (in the form of trip planning) and in-trip travel information (both in waiting areas and on-board). This in-trip information can consist of information useful for occasional passengers (i.e. next stop, connections to other lines/transport modes) or information regarding alternative routes on the case of delays/cancellations. Outwater *et al.* (2011) found that, for non-traditional PT service attributes in Salt Lake City (USA), the highest rated attribute was high-quality real-time service information, above on-board/station amenities and other comfort attributes. This concurs with the findings of dell'Olio *et al.* (2011b), who highlight how the quality of PT service information (e.g. times, delays, platforms) was valued as more important than the level of services available in stations, or a reduction in the level of transfer times. However, despite the importance of such information, it often remains unavailable; González-Díaz and Montoro-Sánchez (2011) state that the main customer complaints regarding bus services in Spain relate to the low-quality waiting areas with little service information, and a lack of a frequent, predictable service.

3.1.1.5 Frequency & Reliability

Frequency and reliability are often regarded as key attributes in determining the quality of a PT service (Redman *et al.*, 2013); only if they are sufficient will the ridership increase during circumstances that favour PT (i.e. high congestion levels, high fuel prices) (Loader and Stanley, 2009). The introduction of urban rail services to connect 11 German towns previously interconnected through a bus system saw a notable increase in ridership, which was mainly attributed to the improvement in reliability and speed (Redman *et al.*, 2013). Furthermore, reliability can also relate to the ability of the passengers to rely on the stated level of service will be provided; Van Exel and Rietveld (2009) state that PT strikes can lead to a permanent loss of ridership between 0.3-2.5%, mainly attributable to passengers deciding that they cannot rely on PT for their mobility requirements.

3.1.1.6 Speed/Journey time

Where a PT service is already running impeded, further increasing the speed of the journey will likely be an economically unsustainable solution. However, where this is not the case, the journey time could be reduced by enabling a greater flow of PT services. For example, priority can be given to PT in specific areas to help assist with PT punctuality at the expense of car users. This may involve developing a segregated right of way for buses/trams, or prioritising PT modes at traffic lights, through the utilisation of such technologies as radio frequency identification (RFID) (Wen, 2008; Koehler and Kraus Jr, 2010). BRT systems commonly enjoy a right of way within cities; a feature that Currie and Delbosc (2011) state is vital to attracting greater ridership.

In urban rail systems, the time difference between a fast and slow service may be as small as 1-2 minutes, suggesting speed is less of an important quality characteristic. This is demonstrated by Graham *et al.* (2009), who found that increasing the speed of urban rail services to slightly reduce journey time had little/no effect on ridership. Indeed, it could be argued that, since speed of the journey is becoming less important with the advances in technology (e.g. WiFi onboard and at

stations), urban travel can in some cases be changed from a derived demand into a valued activity by allowing passengers to enjoy using the PT system (Banister, 2008).

3.1.1.7 Multimodality / Ease of use

To encourage a greater PT ridership by non-/occasional users, it is vital that the PT system is as easy to use as possible – at the core of which is the provision of seamless journeys. Where a journey requires one or more changes, they should be able to be made quickly and simply. This requires both physical and organisational integration within PT modes (e.g. between separate metro lines), between PT modes and between public and private transport modes. It can take the form of integrated ticketing and timetables, and new infrastructure (e.g. higher quality interchanges with bicycle storage, appropriate levels of parking).

The fragmented nature of PT systems within many countries, and even within cities, often leads to different PT operators working against each other, who may also have conflicting aims to that of the local government; illustrating the difficult nature of effecting long-term coordinated efficient PT solutions (Reis *et al.*, 2013). For example, a lack of integration in Istanbul has resulted in such problems as two separate urban rail stations being built in the same location without connections, rather than a single transfer station; problems which decrease service quality and increase the cost of PT (Özgür, 2011).

Integration can also lead to cheaper fares for those using multiple transport modes within one trip; exemplified by the city of Haifa (Israel), who introduced an integrated zonal fare system in place of the per-boarding fare system. This resulted in an 8% increase in the number of trips being made, and a 19% increase in the number of boardings (Sharaby and Shiftan, 2012). The increase in ridership was attributed to both a modal shift from private car transport, and extra journeys being made. However, Milioti and Karlaftis (2014) state that the ridership increase due to the introduction of integrated ticketing may not always be immediate. Furthermore, the city of İzmir in Turkey (metropolitan population approximately 4 million) developed the 'Transformation in Transportation' project, which involved route integration of ferries, buses and urban rail services and the introduction of an integrated ticketing system, leading to a notable increase in the number of passengers carried by the system (Özgür, 2011). Integration between all stakeholders of PT systems could also lead to a greater sharing of information, encouraging high-quality transport information, especially real-time information, to be made available to the public.

Wener *et al.* (2003) reports that it is the transfers in a journey that cause the most stress, emphasising the importance of ensuring they are as simple as possible to make. However, it has been reported that many urban PT systems do not give sufficient consideration to transfers, despite their importance in providing a high-quality journey (Guo and Wilson, 2011). As such, it is important to highlight the importance of such measures to the relevant stakeholders and to hence strive to develop integration – both physical and organisational. The benefits of integration are evidenced in Singapore, where separate agencies and stakeholders successfully work together in a collective manner to provide a high-quality urban rail system, which enjoys a 70% modal share of motorised transport modes (UN, 2013b).

It is also essential that PT integration is managed appropriately, and coordinated in a professional manner. The attempted PT reform in Santiago (Chile) aimed to integrate the PT system, reducing the

number of individual bus routes and changes needed to be made in the average journey, with the aim of lowering car usage. However, the policy makers employed were found to be insufficiently educated in how to design such a scheme, which ultimately led to increased journey times, PT costs and increased private car usage (Gallego *et al.*, 2013)

Interoperability between public and private transport modes is also highly important in attempts to attract non-/occasional PT users. This can be achieved by developing a single method of payment that can be used for multiple purposes, such as the 'Mobility Mixx' card in the Netherlands. This allows citizens to use one card to pay for numerous items, such as PT, taxis, bicycle rental, petrol and park & ride tickets, thus improving ease of use of the PT system (Mobility Mixx, 2013). However, such schemes require high levels of commitment and coordination between all stakeholders, together with sufficient investment, which is discussed further in section 4.

3.1.2 PT Quality Rankings

3.1.2.1 Comparison of different studies

As has been discussed thus far, there are a plethora of studies that assess the importance travellers place on specific PT characteristics, although very few consider numerous characteristics together. After a thorough literature review, five studies were found that consider all or most of the attributes discussed in section 3.1.1, which are analysed herein. All have been undertaken in Europe: a 2008 DfT Opinion Poll (from UK), and four studies from academic literature, Paulley *et al.* (2006) (from UK), De Witte *et al.* (2006) (from Belgium), Stradling *et al.* (2007) (from UK), and Tyrinopoulos and Antoniou (2008) (from Greece). These studies have been designed in a way which provides a ranking of PT requirements by traveller preference (it should be noted that De Witte *et al.* (2006) only considers students). For the purposes of this investigation, these requirements were grouped into seven categories: affordability, accessibility/ease of use, comfort, environmental friendliness, frequency & reliability, safety & security and speed/seamlessness of journey – the traveller requirements considered by the DfT in their hierarchy of transport needs.

This investigation then developed a standardised ranking for each of the five studies considered, so that each study had their PT quality attributes rated from 1-7, where 1 was the most important attribute and 7 was the least. For example, the DfT study found that the most important PT quality attribute was 'Frequency and Reliability', whilst the least important attribute was 'Environmental friendliness'. As such, these were given the rankings of 1 and 7 respectively, which can be seen along with the rest of the results in a visual comparison of the five rankings, shown in Figure 2. Where studies are missing one or two attributes, the ranking is made from 1-6 or 1-5 instead.

Despite the limited number of studies available for analysis, important tendencies can nevertheless be found. For example, this comparison suggests that the most important PT qualities are accessibility/ease of use and frequency/reliability, followed by the comfort/cleanliness levels of rolling stock and waiting areas. The requirement for a safe and secure PT system was not ranked as highly, concurring with the theory postulated previously that citizens intrinsically expect a high level of safety and security in general, and so do not feel the same need to stipulate this when discussing transport preferences. The importance of the comfort of PT services appeared to be higher than is often considered, with three studies rating it either second or third. Indeed, one of the two that states otherwise is the study of students, whose requirements differ from the average citizen; often

placing affordability of transport modes as the quality they value highest. This concurs with the findings of a Transport for London (TfL) study of 16-24 year olds, which found that 57% of those surveyed identified cost as a barrier to increased mobility (Transport for London, 2011b).

Whilst the affordability of the PT service has been previously highlighted as having a notable effect on modal choice, and hence ridership, it is clear from these studies that individuals appear not to consider the cost of a journey important when evaluating its quality, which concurs with the findings of Rojo *et al.* (2012). This analysis has also highlighted that the public either consider the environmental friendliness of PT as an after-thought or label it as a low priority, with some studies even failing to include it in their questions regarding passenger requirements. For instance, the 2008 DfT study found that few participants considered 'environmental friendliness' or 'sustainability' important aspects of their PT system. A consistent opinion throughout the study was that passengers would only start to consider the environmental friendliness of their transport choice once their requirements such as comfort, accessibility, speed, seamlessness of journey, safety, security, affordability and reliability have all been satisfied (Department for Transport (UK), 2008).

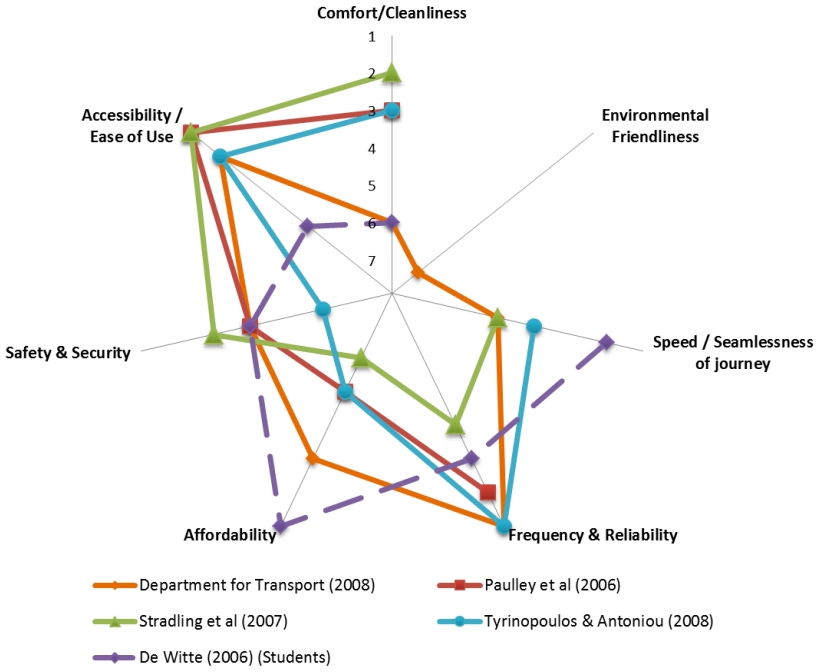

Figure 2: A comparison of the results of the most desired attributes of a public transport system from five different pieces of public opinion research

However, it should be indicated that these findings are very much indicative; the combination of instrumental, situational and psychological factors mean that behaviours and attitudes can vary between different groups of people (Anable and Gatersleben, 2005). Thus, to demonstrate the viability of the results, a model will be required, which is out of the scope of this project. The quality requirements of citizens regarding their transport mode have also been recorded to differ depending on trip type (Anable and Gatersleben, 2005; Passenger Focus, 2012), citizen gender (dell'Olio *et al.*, 2011b; Rojo *et al.*, 2012), citizen income level (dell'Olio *et al.*, 2011b) and citizen age (De Witte *et al.*, 2006). This highlights the problematic nature of focussing upon a specific demographic, demonstrating the need to apply a holistic approach when attempting to effect modal shift. Furthermore, while a set of quality attributes may persuade citizens to use PT in the short

term, they may be very different to those factors which will persuade them to do it in the long term, although Poudenx (2008) states that no specific attribute will make citizens change, rather a combination of factors.

3.1.2.2 Revised hierarchy

The analysis of the PT quality attributes undertaken as part of this investigation have led to the development of a proposed revised version of the DfT's Hierarchy of Transport Needs (Figure 3), based on Maslow's Hierarchy of Needs (Maslow, 1943; Department for Transport (UK), 2008). As with all hierarchical models, the most basic need is shown at the bottom, after which come the more advanced needs, in order of importance, which are only considered once the primary needs have been satisfied. Therefore, it can be inferred that an accessible, easy to use PT system with a frequent and reliable service, followed by comfortable and clean vehicles and waiting areas are the most important quality requirements of a PT system, and as such should be focussed on when attempting to effect modal shift. Subsequently, efforts should logically be focussed on improving the safety and security of the system, before addressing the less important needs above.

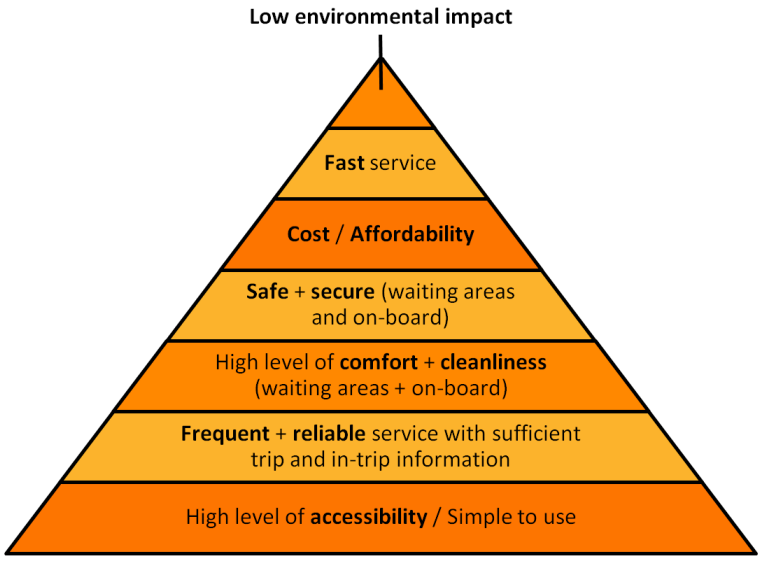

Figure 3: The hierarchical pyramid of public transport passenger requirements

3.2 Push Measures

Where 'Pull' measures are insufficient on their own, habit and attitude research suggests that 'Push' measures can be implemented to create conditions that make car usage either unattractive, difficult or impossible to undertake, thus forcing citizens to change their travel behaviours (e.g. Ronis *et al.* (1989)). They can include methods to reduce car usage (e.g. congestion charging and variable road taxes) and methods to prevent car use (e.g. low emissions zones -restricting access to zero-/low-emissions vehicles).

3.2.1 Congestion Charging

City-wide congestion charging schemes have been implemented in three large cities in Europe – London, Stockholm and Milan – and have achieved varying degrees of success; documented in Table 1. In each instance, traffic levels can be seen to decrease, although there is little change in the modal split between public and private transport modes. Indeed, the reduction in Milan has been almost fully attributed to drivers using an alternative route to travel across the city. Nykvist and Whitmarsh (2008) state that such schemes will have little long-term effect relative to the underlying growth in demand. In particular, Stockholm's success can be drawn from a number of factors: firstly, Stockholm has a low car dependence (the ratio of public to private transport usage during peak time was 70:30 prior to the introduction of the charge); secondly, the scheme coincided with the expansion of (and increase in number of services on) the PT network and thirdly, the congestion charges were marketed as "environmental charges", with an emphasis on the positive effects of air quality (Eliasson and Jonsson, 2011). However, such 'push' measures as congestion charging can prove highly unpopular with citizens. One solution has been to highlight that all revenue would be reinvested in PT services, helping to secure public acceptance of the scheme (Börjesson *et al.*, 2012; EC, 2013b). It is also essential that transport professionals and decision-makers better understand, and engage directly with, the media in such situations, so as to lessen the chances of significant resistance from the public (Vigar *et al.*, 2011).

Table 1: Summary of congestion charging effectiveness

	London [1,2,3,4]	Milan [5]	Stockholm [6,7,8]
Year introduced	2003	2012	2006 (trial scheme) 2007 (permanent)
Initial reduction in traffic levels	18%	>30%	21%
Sustained reduction	10.2% between 2003-2013	-	21%
Effects on modal split	No significant changes to urban rail %; bus % increased slightly.	No observable effects	PT share increased by 3-6%
Environmental effects	'Modest impact' on concentrations of air pollution and life expectancy	33% reduction in PM emissions	14% reduction in CO_2 emissions

1 - (Transport for London, 2004); 2 - (Transport for London, 2006); 3 - (Tonne *et al.*, 2008); 4 - (Transport for London, 2011a); 5 - (EC, 2013b); 6 - (IBM, 2009); 7 - (Börjesson *et al.*, 2012); 8 - (Kottenhoff and Brundell Freij, 2009)

The most important aspect of the London Congestion Charge was its ability to implement a highly controversial urban mobility scheme in spite of significant political and societal resistance. There were two crucial reasons behind the success. Firstly, a greater level of autonomy was granted to new municipal governments, allowing a Mayor of London to be appointed and the process of introducing a congestion charge to be greatly simplified. Secondly a publicity campaign cost approximately £20 million was launched prior to the introduction of the scheme, to ensure the understanding and compliance of the public (Ogilvie *et al.*, 2004). However, an important extension to the scheme in 2006 was removed two years later when a new mayor was voted in on this premise; demonstrating

the problems of effecting a sustainable transport system under the influence of the electoral cycle as it leads to an intrinsic need for those in office to please the electorate to aid their re-election (Chronopoulos, 2012). The challenges in developing greater political strength to circumvent such issues are discussed further in section 4.3.

3.2.2 Parking regulations

Effective management of parking provision can help to encourage modal shift to PT in three ways: firstly, by removing a certain amount of car parking spaces in city centres; secondly, by increasing parking charges within city centres and lastly, by providing higher levels of parking spaces at PT interchanges to encourage travellers to use PT for the final section of their trip.

Removing a certain level of parking spaces within city centres (hence reducing supply) can be an effective tool, and can even be replaced with several bicycle parking spaces (Rajan, 2006; Greater London Authority, 2009). (Beirão and Sarsfield Cabral, 2007) state that tightening parking controls throughout the city, focussing especially on the clamping down of illegal parking (which may increase as a result of reduced parking availability), could lead to a greater usage of PT systems, in cities where it the service is of a sufficient quality.

The cost of parking is regarded as one of the most important individual factors in preventing car usage (Higgins, 1992). Given that commuter trips normally require eight or more hours of parking, it is this traveller demographic that would be most likely to change transport modes on account of parking related factors (Litman, 2013). For example, in New York City (USA), many rail commuters chose rail, despite owning a car, simply because parking was prohibitively expensive (Wener and Evans, 2011). Additionally, Kelly and Clinch (2006) found a 50% increase in the cost of on-street parking in central Dublin reduced demand and duration of stay by 15% and 16.5% respectively. However, the effects of parking regulations need to be carefully considered to avoid adverse congestion-related effects due to a lack of supply (Ibeas *et al.*, 2011). Furthermore, increasing parking charges to encourage modal shift would likely be unpopular; in a 2011 study by the DfT (UK) only 20% of respondents considered increasing parking charges as an acceptable way for the government to encourage greater PT usage. By contrast, 62% stated that funding PT quality improvements would be much more acceptable (Department for Transport (UK), 2011).

Problematically, the effects of parking restrictions alone are difficult to isolate, since they are often implemented as part of a package of mobility management measures. For example, parking restrictions, improved PT services and walking/cycling infrastructure and information campaigns were introduced in the area surrounding a business park providing 21,000 jobs. As a result, the modal split of private car usage was reduced from 60% to 42%, with PT usage increasing from 21% to 38% over the ten year period after the changes were implemented (EC, 2009c).

Park and ride schemes have enjoyed mixed success in effecting a modal shift to PT in urban areas. If planned correctly with sufficient, safe and well-lit parking, they can reduce congestion levels whilst also allowing non-/occasional PT users to become more familiar with using PT (Blainey *et al.*, 2012). However, the success of such initiatives will depend on their effective coordination and integration with other urban policies, and by providing a high-quality PT alternative. As has been highlighted in section 2, the public prefer rail over bus; perceiving it as a higher quality service, suggesting that the parking availability at urban rail stations could be crucial in helping to encourage greater PT usage.

Such stations could provide electric vehicle charging points, which could be powered by regenerative braking energy from the urban rail rolling stock (Falvo *et al.*, 2011; González-Gil *et al.*, 2014). Santos *et al.* (2010b) report how a greater provision of car parking facilities at urban rail stations on the periphery of American cities moved private car users to urban rail. Several bus-based park and ride schemes have been found to be ineffective; either by resulting in no change to the modal split between transport modes, or in some reported cases actually leading to increased car usage (Mingardo, 2013). Furthermore, while reducing congestion in the city centre, park and ride still encourages a significant portion of the journey to be made using a private car, contrary to the aims of sustainable mobility.

3.2.3 Urban Planning/ Form

Pedestrianisation of streets can also be an effective tool to control car usage, but also to increase PT service punctuality and improve pedestrian quality of life. This can lead to environmental benefits (reduced noise and air pollution), increased safety, social and cultural benefits, tourism benefits (due to improved aesthetics) and economic benefits (through increased commercial activity) (Sastre *et al.*, 2013). There are several manners in which this may be effected. Firstly, it can involve lowering the speed limit and removing street furniture/common traffic regulation furnishings, thusly increasing the aesthetic appeal of the street and making car users pay more attention to their surroundings (Gatersleben *et al.*, 2013). Secondly, it may also further involve cars being banned from the street, helping to avoid PT modes being stuck in traffic jams consisting of private cars. Finally, streets can be fully pedestrianised, fully opening up the street to the public, helping to develop relaxed public spaces that can be used for multiple activities (Kärrholm *et al.*, 2014). However, the successful implementation of such measures requires sufficient capacity on alternative routes/modes of transport, and strong political commitment to implement such schemes in the face of adversity from private car users.

4. Overcoming the barriers to modal shift

Section 3 has highlighted that a number of challenges exist to successfully effecting any notable level of modal shift from private to public transport. It has been observed that societal and political issues lie at the heart of many of these problems, and as such, five areas to aid the circumvention of these challenges are discussed in this section.

4.1 Internalising externalities

The European Commission's Transport White Paper states that one of the main challenges towards achieving sustainable mobility is internalising the externalities associated with private car usage in urban areas (EC, 2011). A strategy by which this could be achieved was outlined in 2008 by the European Commission in their communication "Strategy for the internalisation of external costs" (EC, 2008b). These externalities are the differences between the private costs borne by the user themselves using the transport mode, and the actual real-life social costs, and can consist of such aspects as accident levels, congestion levels (and the associated noise/pollutant emissions), oil dependence and other social costs (Maibach *et al.*, 2007; Santos *et al.*, 2010a). Congestion is the externality which has currently attracted the largest share of attention from transport professionals (Basso and Jara-Díaz, 2012), given its demonstrable negative economic effects. The role of transport policy is not to eradicate the car, but rather to establish high-quality alternatives to the car to

eliminate the need for one (Van Exel and Rietveld, 2009). To do this, the cost to the user of undertaking their trip using a specific transport mode has to accurately reflect the externalities that this trip produces, with private car usage leading to the greatest level of externalities (Maibach *et al.*, 2007). However, methods to achieve this with regard to road transport (e.g. variable road user charging and congestion charging) are usually met with significant public resistance and as such will require a greater combination of political will and societal acceptance (e.g. Vigar *et al.* (2011)).

4.2 Societal backing and cooperation

Societal issues have an important role to play in the design of transport policy, and hence the success of attempts to instigate modal shift, although such issues are often less well researched/addressed than the associated economic or environmental considerations (Lucas and Jones, 2012). To achieve the societal backing and cooperation necessary, a high quality, efficient and attractive system needs to be provided that considers the needs of the public, whilst addressing the incorrect, negative perceptions citizens often have towards public transport and promoting pro-environmental behaviours. These factors are discussed in turn.

4.2.1 Provision of an attractive, easy to use system

The PT system itself needs to be attractive to citizens, and easy to use. This paper has illustrated the effects of improving PT service quality attributes, and the relative importance of each (e.g. Figures 2 and 3). Innovative technologies can also help to heighten the appeal of PT; for example, the rapid rise in smartphone users can allow for bespoke applications to be developed, which can include live travel information/travel planning capabilities. Indeed, a survey of passengers aged 15-29 found 60.9% considered such tools either 'essential' or 'very useful', with a further 33.8% stating it would be 'rather useful' (Bak *et al.*, 2014). Nevertheless, the elderly often do not have access to such enabling technologies, which must be considered to avoid their exclusion. The use of contactless payments, either by wireless internet or Near Field Communication (NFC) would also help the PT system become easier and more attractive to use. Additionally, trams with an onboard energy storage device can store and use energy from the catenary and regenerative braking to travel through aesthetically pleasing/historic parts of cities without the need for a catenary, hence minimising social intrusion and improving the image of PT (González-Gil *et al.*, 2013). However, it is important that improvements to the system leave the public unaffected; Friman (2004) describes how passenger opinions of the PT system quality declined in the face of improvements to the reliability and frequency of the service due to the level of disruption caused during the implementation of the improvements

Additionally, societal involvement in PT decision-making is vital to develop a greater understanding of the needs of all stakeholders. For example, in Barcelona, several newspapers publish daily columns on mobility-related issues, with a specific section dedicated to readers writing in with queries or comments about the PT system (UN, 2013b). Furthermore, this is also a platform for the responsible organisation(s) to respond to the writers, helping to allow the users to feel included and understood, which has been noted to help develop a higher level of public acceptance of their PT system (UN, 2013b).

4.2.2 Addressing perceptions

The public's perception of PT can be considered as important as the actual service quality itself; it is the perception of PT service quality attributes that govern whether people consider PT as a viable alternative to the private car, and hence whether modal shift can be effected to any meaningful level. PT is frequently portrayed as the mode of transport for those who cannot afford a private car, and it is vital that this perception is addressed. Furthermore, there exist many cases where there is a significant disparity between the actual service quality levels of PT and the perceived quality levels by non-/occasional users, who often consider it unclean, unreliable, unsafe and uncomfortable – commonly to a degree that cannot be justified (Fujii and Kitamura, 2003; Beale and Bonsall, 2007; Beirão and Sarsfield Cabral, 2007; Stradling *et al.*, 2007; dell'Olio *et al.*, 2011a). These include overestimations of journey time, average wait time and fare level, whilst crucially underestimating both the journey time taken when travelling by car (citizens rarely take into account time costs such as refilling the petrol tank and finding parking spaces) and the actual operating costs of their own cars. Furthermore, in a survey of over 27,000 bus and train commuters in the Netherlands, Van Exel and Rietveld (2009) found that people think they spend much longer on PT than they actually do, going on to suggest that if non-/occasional PT users were informed of how long PT journeys actually took, two thirds would consider PT as a viable option. This demonstrates the importance for Local Authorities and Operators to engage in high-visibility, widespread marketing to help remove such incorrect perceptions, which Outwater *et al.* (2011) state could have a significant positive effect on ridership levels.

Nevertheless, such opinions vary; in a residential area of Stockholm (Sweden) 90-95% of residents were knowledgeable about the bus provision in their area, including its number and operational times (Kottenhoff and Brundell Freij, 2009). However, it is not simply about the perceptions of the public; Redman *et al.* (2013) state that PT operators have a different perception of the quality levels of their own services in comparison to quality assessments by passengers, which can affect their opinions on whether it needs to be improved.

4.2.3 Promoting pro-environmental behaviour

However, the benefits to society (e.g. improved health, reduced stress, greater productivity etc) from a modal shift are not necessarily acknowledged or appreciated by the majority of the travelling public, especially non-/occasional PT users (e.g. Beale and Bonsall (2007); Department for Transport (UK) (2008)).

This paper has highlighted that, without the motivation, the public are not likely to engage in any notable level of modal shift, and it has been postulated that it would be easier to persuade citizens to move from private to public transport if they were more interested in pro-environmental issues. However, generating pro-environmental behaviours amongst regular citizens is often a difficult and slow process, especially since the complexity of societal behaviours can vary greatly between different countries and even within cities (Freestone and McGoldrick, 2008; Nykvist and Whitmarsh, 2008; Collier *et al.*, 2010).

Figure 3 has illustrated how most citizens will only consider the environmental credentials of their transport mode once their many other, more important, needs have been met. In the UK, three main methods have been employed to encourage pro-environmental behaviour amongst citizens:

the provision of environmental information; the incremental introduction of environmental regulations and the use of environmental taxes and charges (Lucas *et al.*, 2008). However, it is evidenced that only those methods which make environmental behaviour economically superior to its alternatives will succeed in developing any noticeable level of behavioural change; one of the main reasons why the inclusion of a transport mode's externalities should be included in the cost of the journey is of vital importance (Lorenzoni *et al.*, 2007; Marsden and King, 2009; Van Exel and Rietveld, 2009; Department for Transport (UK), 2011). However, research suggests that a certain level of pro-environmental behaviour could be effected by highlighting self-transcendent reasons, rather than self-enhancing reasons. For example, this could involve highlighting that a preserving a forest for its natural beauty, rather than for its economic worth (Crompton, 2010). Therefore, the inclusion of such justifications, in addition to the benefits and necessity of modal shift, in an information-based campaign aimed at removing false perceptions of PT could prove beneficial.

4.3 Political Commitment

At present, policies/legislation to encourage such a modal shift are currently lacking. This is a challenging area; since politicians have to take into account societal opinions/requirements (where the motoring sector is highly vocal), issues arise when trying to implement such policies/legislation (John and Cole, 1999; Banister, 2008). However, often the perceptions of policy makers on public opinion are more negative than can be actually justified (Banister, 2008; Cohen, 2012), demonstrating the need to better understand the requirements of the travelling public, to allow new urban mobility policies to succeed. This is especially problematic, as changes greater than ever need to be effected, the success of which relies upon committed, educated legislators fostering long-term, inclusive policies considering mobility, land use and the economy together. However, the ability to implement such necessary, but often controversial, policies and schemes to encourage modal shift is hampered by a lack of political strength, often through disagreements between politicians and councillors, which can even lead to a complete stagnation in progress (Stern, 2012). It is also necessary that political leadership is transparent and accountable, enhancing citizens' trust in the organisation and ensuring flagship policies of an individual/party do not collapse when their term in office ends.

It must be impressed upon politicians that these challenges are political challenges, requiring appropriate political consultation, decisions and implementation, rather than simply a technological challenge requiring a simple solution. Nevertheless, calling for greater political will is insufficient; the problem is most commonly caused by pre-existing factors that need to be addressed, such as the current legislative process (Spence *et al.*, 2010). Methods to encourage a modal shift from private to public transport will also be difficult to implement given the resistance by the vested interests of powerful societal actors, such as car and petrol manufacturers, further necessitating strong, independently-minded politicians who can address this (Vergragt and Brown, 2007).

There is evidence to suggest that some politicians/councillors lack an understanding of mobility and environmental issues and the capabilities of the technologies with which to address them (Cohen, 2012). Therefore, providing decision-makers with guidance on such issues may help to ensure they make their decisions with sufficient knowledge. However, this is not limited to the aforementioned parties; it is also necessary to ensure civil servants/administrative staff are fully educated and committed – even if there is political agreement on a controversial topic, if the administrative staff

do not believe it can, will or should happen, then the likelihood of implementation is low (Hrelja *et al.*, 2013).

The developing of panels of independent experts who would provide comprehensive, accurate impartial and transparent advice to decision-makers, reflecting the requirements of all relevant stakeholders (e.g. the UK Committee for Climate Change) could prove useful in ensuring decision makers take sufficiently educated decisions. Where political strength is still insufficient, a solution may be to legislate that such recommendations are mandatory; although developing truly independent committees will itself prove challenging to develop.

It has also been highlighted that operators/policy makers often fail to accurately predict public opinion, often underestimating the public's acceptance of certain policies leading to a hesitation in implementing them. It is necessary to address this minimal involvement of citizens and community interests in the planning, design and operation of urban transport. Potential solutions include the use of passenger advisory boards to advise operators/policy makers on the acceptance of legislation/schemes to be implemented, to provide conviction, and the social participation discussed in the aforementioned case study of Barcelona.

4.4 Investment

Three criteria need to be met before PT is a viable alternative to private motoring, and any notable level of modal shift can occur: Firstly, it will be necessary to improve PT of an inferior quality to an appropriate level; secondly, capacity improvements should be developed (where necessary) to accommodate an increase in ridership and lastly, sufficient 'push' mechanisms should be introduced to facilitate in attitudinal change which will aid a reduction in car use (e.g. low emissions zones, congestion charging, carbon taxes/variable road taxes). To achieve these targets, significant levels of investment are required; indeed, the European Economic and Social Committee estimate that over €3 trillion will be necessary to develop a high-quality European transport system (EC, 2012). For example, Loader and Stanley (2009) report how the city of Melbourne spent $1.4 billion over a ten-year period improving bus service frequency and quality within the city. This yielded a Cost-Benefit Ratio of 3.0, despite most extra journeys being undertaken for social interactions.

Given the current levels of austerity and the costs and risks to the public sector inherent in construction and maintenance, alternative sources to public funding will be required. Private-sector investment is a promising area that could be explored further, since private investors hold PT in high regard, due to its demonstrable strengths (e.g. stable revenue and cash flow, clear potential for growth, status as a provider of essential services). Hence, they are often willing to invest in the necessary infrastructure, where there is sufficient impetus to do so (i.e. long-term concessions) (Di Pietrantonio and Pelkmans, 2004). However, it is important to clearly define all contractual agreements and to thoroughly examine the risks associated with the partnership to reduce the likelihood of the partnership breaking down; an overemphasis on contractual concerns rather than providing a quality service can hinder the success of the partnership, taking the focus away from more important issues (Macário and Jara-Diaz, 2008).

Maximising the exploitation of PT assets through the coordination of transport developments with private land developments is a useful strategy; accessibility benefits usually translate into increased land prices and higher density concentrations of commercial activities along the route served by the

transport mode. This is mainly the case for urban rail systems, on account of its permanent nature and more efficient use of land although some BRT systems also lead to such benefits (Rodriguez and Targa, 2004; Calthorpe, 2011). For example, in 2012, the Hong Kong metro system recouped 149% of its operating costs from revenue generated by the system, which is attributed to its efficient integration of urban land use planning and transport planning (UN, 2013b). Additionally, Portland (USA) achieved notable success in this area, with every dollar of public investment in PT leading to $31 of private investment. Furthermore, the 1999 redevelopment of the Köln Deutz/Messe railway station and the surrounding area included in its design a 75,000m^2 hotel, a retail centre, an entertainment complex and over 100,000m^2 of office space, leading to the potential for much shorter and hence sustainable trips to be made (Fentress Bradburn, 2001; Calthorpe, 2011).

Furthermore, SEPTA of Philadelphia sold 250,000 three-day passes to the international deal website Groupon for $1.8 million, with the aim of encouraging more people to try its PT services and become more open to engaging in future modal shift (Schlosser, 2013).

4.5 Modal Shift Research & Programmes

Specific modal shift programmes and behavioural studies targeting a specific demographic or PT attribute have been undertaken for many decades, the findings from a number of which have already been discussed in this paper. Such studies and programmes have developed a series of individual recommendations on how to best effect modal shift, necessitating a holistic approach which amalgamates the findings of such studies into one series of recommendations.

It can be argued that there is a case for more focussed programmes aiming to instigate modal shift among non-/occasional users of PT. For example, Lee and Senior (2013) found multiple car ownership increased by a greater proportion in UK cities where a light rail system had been installed, in comparison to similar-sized cities, suggesting a high quality PT system may (on its own) be insufficient to facilitate modal shift. Furthermore, the modal split between transport modes has remained relatively constant in recent years, and attempts to facilitate modal shift towards PT have failed to reach their full potential, whilst badly-designed modal shift programmes can even result in the reinforcing of negative, pro-car behaviours (Beale and Bonsall, 2007). This can be partially attributed to poor dissemination of the findings of such programmes (Davison and Knowles, 2006; Redman *et al.*, 2013).

Several modal shift programmes have already been discussed, such as those in Hasselt and Austin, where fare-free PT was introduced to encourage greater ridership, especially modal shift from private transport. Additionally, (Gould and Zhou, 2010) document how, in 2008, the University of California, Los Angeles provided a free 12-week PT pass for all employees who handed in their parking pass for that period. After this trail period, the 381 participating employees were offered their parking passes back, or the opportunity to purchase PT passes (subsidised to half-price). Of the 381 employees, 70% continued to use PT after the trial had ended. They were recorded to have familiarised themselves with PT routes and schedules and found travelling by bus less stressful than driving (Gould and Zhou, 2010). The length of the scheme is also critical to success, with one day (Beale and Bonsall, 2007), one week (AD PERSONAM, 2010), and even one month (Fujii and Kitamura, 2003; Thøgersen, 2009) being suggested as insufficiently long to break habits.

The use of Corporate Mobility Management (CMM) as a tool to effect modal shift has been posturised. This involves workplaces, typically the main employers, such as LAs, promoting/requiring sustainable commuter, business and customer travel. However, in practice CMM is difficult to effect; when plans were developed to force the Local Authority of Örebro (Sweden) to implement CMM, disagreements between politicians and transport administrators led to the radical nature of the proposals being significantly watered down, becoming 'guidelines' rather than 'rules' (Hrelja *et al.*, 2013).

However, all potential outcomes of such schemes (for participants and non-participants) must be considered prior to its implementation. For example, the TravelSmart scheme in Adelaide (Australia) achieved a reduction of the car usage of the 10,000 households participating in the scheme by 14% (229,850 vehicle-km/day) over the 18-month trial period. However, the non-participants (whose travel behaviour was also monitored) increased their vehicle-km travelled by 37% (605,030 vehicle-km/day. Since this increase in the non-participants group is highly unlikely to be unrelated to the positive effects of the scheme, this suggests the scheme had a detrimental effect on the environment (Government of South Australia, 2009). Furthermore, the City of Mexico government introduced a ban on vehicle usage within the Mexico City Metropolitan Area, whereby vehicles were prevented from entering the city on one day each week depending on the number plate of their car. The main aims of this scheme were to encourage PT usage and mitigate against the environmental and economic burden brought about by the congestion from the increase in private car usage within the city. However, this plan backfired; resulting in 38% of households in the affected area purchasing an additional (often a cheaper, more polluting) car in a bid to circumvent the ban, rather than use the low-quality PT system (Crotte *et al.*, 2011).

This investigation has already discussed a number of good and bad practices regarding the design and execution of modal shift schemes, derived from a number of case studies. However, many more examples exist. Given the importance and benefits of such schemes in encouraging modal shift, an extensive literature review of recommendations on the design of modal shift schemes was additionally undertaken. This covered industry reports on modal shift schemes, findings from behavioural studies and relevant academic literature. To the knowledge of the authors, an amalgamation of all such findings has not previously been undertaken in academic literature. As a result of this, a brief summary of good practices for the design of modal shift schemes has been complied, and is displayed in Table 2, which are relevant for all sizes of urban areas. Consideration of these recommendations will help to maximise the effectiveness of future modal shift schemes.

Table 2: A summary of good practices from literature to follow during the design and execution of future modal shift schemes

	Guidelines	Reason
Projects	Should focus on homogenous groups (i.e. workplaces and clubs)	Encourages people to be open to accepting new information, due to a higher level of mutual trust. Focussing on workplaces would also allow for employer backing (i.e. CMM) [1,2,3,4,18]
	Should emphasise tackling the issue as a group	Allows individuals to support/encourage each other (e.g. TravelSmart's focus on families) [5]
	Should include representation by those the public admire (i.e. celebrities / other well-known figures)	The public can associate themselves with them and accept their messages more easily [3,6]
	Should aim to break the habit of car usage for a sustained period of time (e.g. free/discounted PT passes)	Breaks habits, removes incorrect perceptions of PT service quality and gives a realistic chance for the user to appreciate PT as a viable alternative to the private car [7,8,9, 21]
	Must consider all possible outcomes of the scheme to help avoid negative results	Failure to asses all outcomes has led to detrimental effects in Australia and Mexico [5,19]
	Organise the trial period to be in the summer months.	This will decrease the likelihood of bad weather during the trial period, which has been shown to put off non-/occasional PT users from using PT [3]
Information Content / Provision	Transparent, credible and balanced, acknowledging weaknesses of PT	To demonstrate the information provider is being fair and help non-users affirm themselves with the message [9,10]
	Emphasises health benefits of PT usage over private cars	Citizens are more accepting of arguments given from a health point of view [11]
	Does not worry/frighten readers or guilt/criticise non-users transport choices	Causes readers to disengage [6,12]
	Highlights true cost/time associated with car ownership	Many people are unaware of true cost [9]
	Tailored to individuals where possible	To increase likelihood of acceptance, as opinions of the public regarding energy efficiency, PT and climate change vary greatly [1,9,13,14]
	All messages should be consistent and frequently repeated	To keep the issues in people's minds [15]
	Should include basic facts on the benefits to the environment.	Aids understanding of the necessity of modal shift and can help effect pro-environmental beliefs to encourage behavioural change [20]
	Should be provided by credible and transparent institutions	Individuals are more likely to accept information from these sources [3]
	These organisations should be represented by credible, motivated and committed professionals	Scientists / people within the individual's social networks are considered the most trustworthy [16,17]

1 - (Corner and Randall, 2011); 2 - (Sustrans, 2009); 3 - (AD PERSONAM, 2010); 4 - (Abroms and Maibach, 2008); 5 - (Government of South Australia, 2009); 6 - (Platt and Retallack, 2009); 7 - (Thøgersen, 2009); 8 - (Fujii and Kitamura, 2003); 9 - (Beale and Bonsall, 2007); 10 - (Young and Middlemiss, 2012); 11 - (Litman, 2013); 12 - (De Hoog *et al.*, 2005); 13 - (Spence *et al.*, 2010); 14 - (Leiserowitz *et al.*, 2010); 15 - (Moser and Dilling, 2004); 16 - (MORI, 2005); 17 - (Poortinga and Pidgeon, 2003); 18 - (Hrelja *et al.*, 2013); 19 - (Crotte *et al.*, 2011); 20 - (Lorenzoni *et al.*, 2007); 21 - (Ronis *et al.*, 1989)

5. Recommendations to facilitate in effecting modal shift

From the holistic analysis carried out in this paper, a series of general recommendations to better effect modal shift have been developed, the consideration of which will be at the core of any notable success in effecting modal shift from private to public transport. These recommendations are aimed at providing guidance, specifically at those in decision-making positions who can influence the success of attempts to effect modal shift. A summary of these recommendations is shown in Table 3.

Table 3: A summary of recommendations to facilitate in effecting modal shift

Operators
• Operators should take care that quality of service is not notably reduced during quality improvements to the system. • The use of innovative technologies/approaches can improve the appeal of PT systems • Operators should consider the hierarchy of PT needs (Figure 3) to ensure focus is given to the quality attributes most effective at encouraging modal shift. • The effectiveness, cost-effectiveness and feasibility of PT quality improvements should be considered when apportioning investment. • The way the public ranks PT quality characteristics, and the way they choose their transport mode are not always similar and should be acknowledged when attempting to implement PT quality improvements to encourage modal shift. For example, cost is an important factor in the choice of mode, but passengers do not view affordability as a key PT quality requirement.
Governments / Local Authorities
• Methods to circumvent the constraining effects of the electoral cycle and the lack of political strength to allow for a long-term sustainable transport system should be investigated further. • Legislation should be developed to encourage contractual agreements that promote longer-term thinking and maximise private investment in PT infrastructure. • Development of Passenger Transport Authorities to encourage integration and interoperability between all urban transport modes. • Passenger advisory boards should be further utilised to provide their reaction and advice to policy-makers and operators regarding urban mobility policies, since it appears that such stakeholders perceive the acceptability of stringent policies to be much lower than it actually is. • Both decision-makers and the general public should be educated in sustainable mobility issues, including the necessity of a modal shift to PT. • Relevant stakeholders should consider the overall long-term benefits of PT system improvements, including their effects on land prices. • When developing future programmes aiming to instigate modal shift, decision makers should be aware of the recommendations listed in Table 2 on the design of such programmes, in addition to their potential negative consequences (i.e. in Australia, Mexico and USA). • Where measures to control car usage are necessary, consideration should be given to the range of potential positive and negative consequences of such actions before implementation. • Fare-free transport is not a sustainable, long-term solution to reducing car usage, since it can lower the level of walking/bicycling journeys made, and does not effect a high enough level of modal shift to compensate for the loss of revenue and increased overcrowding. • Decision-makers should explore innovative measures to provide funding, with a focus on private investment.

6. Conclusions

This investigation has highlighted the importance of modal shift in achieving sustainable urban mobility. However, it has been underlined that the nature of this challenge is intrinsically complex, with many interrelating factors determining the likelihood of successfully achieving a notable level of modal shift. These include societal factors, political factors and a lack of understanding of system-level effects of certain measures to encourage greater patronage. This has demonstrated the need for a holistic approach that considers the needs of all involved stakeholders, including policy makers, PT operators, industrial partners and travellers themselves, which has not previously been undertaken in academic literature. As such, this paper has undertaken a thorough analysis of academic literature and numerous case studies, developing a series of highly relevant findings. The effects of individual quality attributes on ridership levels have been investigated (section 3), accompanied by an examination of how individuals prioritise specific PT attributes when considering the quality of a PT journey. Furthermore, the effects of a series of 'push' mechanisms to discourage car usage on modal shift have been analysed. When attempting to instigate significant levels of change, in terms of infrastructure, PT operations and behavioural changes, there are intrinsically numerous challenges to success. As such, several methods which can be used to circumvent many of these challenges have been discussed (section 4). The findings and recommendations from this investigation for those in decision-making positions have thusly been amalgamated in section 5. If delivered as part of a comprehensive package of policies, rather than implemented individually, with an appropriate level of societal backing, political will and investment, this will facilitate in the progression to a sustainable, high-quality future transport system.

Abbreviations

BRT: Bus Rapid Transit

CMM: Corporate Mobility Management

DfT: United Kingdom Department for Transport

EU: European Union

LA: Local Authority

PT: Public Transport

TfL: Transport for London

UK: United Kingdom

References

Abroms, L.C. and Maibach, E.W. (2008) 'The effectiveness of mass communication to change public behavior', *Annual Review of Public Health*, 29, pp. 219-234.

AD PERSONAM (2010) *Hop on! Direct Marketing: a new way to boost Public Transport [Recommendations from the EU Project]*. Available at: http://www.eltis.org/docs/tools/Hop_on_guide_en.pdf.

Aditjandra, P.T. (2013) 'The impact of urban development patterns on travel behaviour: Lessons learned from a British metropolitan region using macro-analysis and micro-analysis in addressing the sustainability agenda', *Research in Transportation Business & Management*, 7(0), pp. 69-80.

Anable, J. and Gatersleben, B. (2005) 'All work and no play? The role of instrumental and affective factors in work and leisure journeys by different travel modes', *Transportation Research Part A: Policy and Practice*, 39(2-3 SPEC. ISS.), pp. 163-181.

Bak, M., Borkowski, P. and de Stasio, C. (2014) 'Transferability of ICT solutions for improving co-modality in passenger transport', *Transport Research Arena*. Paris, France, 14/04/2014-17/04/2014.

Banister, D. (2008) 'The sustainable mobility paradigm', *Transport Policy*, 15(2), pp. 73-80.

Banister, D. and Thurstain-Goodwin, M. (2011) 'Quantification of the non-transport benefits resulting from rail investment', *Journal of Transport Geography*, 19(2), pp. 212-223.

Basso, L.J. and Jara-Díaz, S.R. (2012) 'Integrating congestion pricing, transit subsidies and mode choice', *Transportation Research Part A: Policy and Practice*, 46(6), pp. 890-900.

Beale, J.R. and Bonsall, P.W. (2007) 'Marketing in the bus industry: A psychological interpretation of some attitudinal and behavioural outcomes', *Transportation Research Part F: Traffic Psychology and Behaviour*, 10(4), pp. 271-287.

Beirão, G. and Sarsfield Cabral, J.A. (2007) 'Understanding attitudes towards public transport and private car: A qualitative study', *Transport Policy*, 14(6), pp. 478-489.

Ben-Akiva, M. and Morikawa, T. (2002) 'Comparing ridership attraction of rail and bus', *Transport Policy*, 9(2), pp. 107-116.

Blainey, S., Hickford, A. and Preston, J. (2012) 'Barriers to Passenger Rail Use: A Review of the Evidence', *Transport Reviews*, 32(6), pp. 675-696.

Börjesson, M., Eliasson, J., Hugosson, M.B. and Brundell-Freij, K. (2012) 'The Stockholm congestion charges—5 years on. Effects, acceptability and lessons learnt', *Transport Policy*, 20(0), pp. 1-12.

Calthorpe, P. (2011) *Urbanism in the age of climate change*. Washington D.C. (USA): Island Press.

Cao, J. (2013) 'The association between light rail transit and satisfactions with travel and life: Evidence from Twin Cities', *Transportation*, 40(5), pp. 921-933.

Chronopoulos, T. (2012) 'Congestion pricing: The political viability of a neoliberal spatial mobility proposal in London, Stockholm, and New York City', *Urban Research and Practice*, 5(2), pp. 187-208.

Cohen, T. (2012) 'Can participatory emissions budgeting help local authorities to tackle climate change?', *Environmental Development*, 2(0), pp. 18-35.

Collier, A., Cotterill, A., Everett, T., Muckle, R., Pike, T. and Vanstone, A. (2010) *Understanding and Influencing Behaviours: A Review of Social Research, Economics and Policy Making in Defra*. London. [Online]. Available at: http://archive.defra.gov.uk/evidence/series/documents/understand-influence-behaviour-discuss.pdf (Accessed: 19/02/2013).

Corner, A. and Randall, A. (2011) 'Selling climate change? The limitations of social marketing as a strategy for climate change public engagement', *Global Environmental Change*, 21(3), pp. 1005-1014.

Cox, T., Houdmont, J. and Griffiths, A. (2006) 'Rail passenger crowding, stress, health and safety in Britain', *Transportation Research Part A: Policy and Practice*, 40(3), pp. 244-258.

Crompton, T. (2010) *Common Cause: The case for working with our cultural values*. Surrey: (UK), W.W.F.

Crotte, A., Graham, D.J. and Noland, R.B. (2011) 'The Role of Metro Fares, Income, Metro Quality of Service and Fuel Prices for Sustainable Transportation in Mexico City', *International Journal of Sustainable Transportation*, 5(1), pp. 1-24.
Currie, G. and Delbosc, A. (2011) 'Understanding bus rapid transit route ridership drivers: An empirical study of Australian BRT systems', *Transport Policy*, 18(5), pp. 755-764.
Davison, L.J. and Knowles, R.D. (2006) 'Bus quality partnerships, modal shift and traffic decongestion', *Journal of Transport Geography*, 14(3), pp. 177-194.
De Hoog, N., Stroebe, W. and De Wit, J.B.F. (2005) 'The impact of fear appeals on processing and acceptance of action recommendations', *Personality and Social Psychology Bulletin*, 31(1), pp. 24-33.
De Witte, A., Macharis, C., Lannoy, P., Polain, C., Steenberghen, T. and Van de Walle, S. (2006) 'The impact of "free" public transport: The case of Brussels', *Transportation Research Part A: Policy and Practice*, 40(8), pp. 671-689.
Delbosc, A. and Currie, G. (2012) 'Modelling the causes and impacts of personal safety perceptions on public transport ridership', *Transport Policy*, 24, pp. 302-309.
dell'Olio, L., Ibeas, A. and Cecin, P. (2011a) 'The quality of service desired by public transport users', *Transport Policy*, 18(1), pp. 217-227.
dell'Olio, L., Ibeas, A., Cecín, P. and dell'Olio, F. (2011b) 'Willingness to pay for improving service quality in a multimodal area', *Transportation Research Part C: Emerging Technologies*, 19(6), pp. 1060-1070.
Department for Transport (UK) (2008) *Public Attitudes to Transport DfT's On-line Citizens' Panel* [Online]. Available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/11508/climate-change-2011-report.pdf (Accessed: 13/08/2012).
Department for Transport (UK) (2011) *Public attitudes to climate change and the impact of transport in 2011*. [Online]. Available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/11508/climate-change-2011-report.pdf (Accessed: 27/11/2012).
Di Pietrantonio, L. and Pelkmans, J. (2004) *The Economics of EU Railway Reform*. Bruges: Briefings, B.E.E.P. [Online]. Available at: http://www.coleurope.eu/sites/default/files/research-paper/beep8.pdf.
EAC (2010) *Air Quality (5th Report)*. [Online]. Available at: http://www.publications.parliament.uk/pa/cm200910/cmselect/cmenvaud/229/22902.htm (Accessed: 30/01/2013).
Directive 2008/50/EC on ambient air quality and cleaner air for Europe.
EC (2008b) *Strategy for the internalisation of external costs*.European Commission,. [Online]. Available at: http://www.eea.europa.eu/policy-documents/com-2008-435.
Decision No 406/2009/EC on the effort of Member States to reduce their greenhouse gas emissions to meet the Community's greenhouse gas emission reduction commitments up to 2020.
Directive 2009/28/EC on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC.
EC (2009c) *Lloyd District Partnership Plan in Portland, USA*. Available at: http://www.eltis.org/index.php?id=13&study_id=2517 (Accessed: 10/03/2014).
EC (2011) *Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system*. Brussels: European Commission,.
EC (2012) *Opinion of the European Economic and Social Committee on 'The prospects for sustainable employment in rail, rolling stock and infrastructure: how industrial change will influence the European employment and skills base'* Brussels: European Commission,.
EC (2013a) *Hasselt cancels free public transport after 16 years*. Available at: http://www.eltis.org/index.php?ID1=5&id=60&news_id=4183 (Accessed: 25/02/2014).

EC (2013b) *Milan: lessons in congestion charging*. Available at: http://ec.europa.eu/environment/ecoap/about-eco-innovation/good-practices/italy/20130708_milan-lessons-in-congestion-charging_en.htm (Accessed: 03/11/2013).
EC (2014) *Commission takes action against UK for persistent air pollution problems [Press Release]*. Available at: http://europa.eu/rapid/press-release_IP-14-154_en.htm (Accessed: 04/03/2014).
Eliasson, J. and Jonsson, L. (2011) 'The unexpected "yes": Explanatory factors behind the positive attitudes to congestion charges in Stockholm', *Transport Policy*, 18(4), pp. 636-647.
Falvo, M.C., Lamedica, R., Bartoni, R. and Maranzano, G. (2011) 'Energy management in metro-transit systems: An innovative proposal toward an integrated and sustainable urban mobility system including plug-in electric vehicles', *Electric Power Systems Research*, 81(12), pp. 2127-2138.
Farla, J., Alkemade, F. and Suurs, R.A.A. (2010) 'Analysis of barriers in the transition toward sustainable mobility in the Netherlands', *Technological Forecasting and Social Change*, 77(8), pp. 1260-1269.
Fentress Bradburn (2001) *Fentress Bradburn: Selected and Current Works*. Australia: The Images Publishing Group.
Foote, P.J. (2004) 'Making Buses Better In Chicago: Strategic Implementation Of Customer-Derived Performance Measures From 1995 To 2001', *Transportation Research Record*, (1884), pp. 18-26.
Freestone, O.M. and McGoldrick, P.J. (2008) 'Motivations of the ethical consumer', *Journal of Business Ethics*, 79(4), pp. 445-467.
Friman, M. (2004) 'Implementing Quality Improvements in Public Transport', *Journal of Public Transportation*, 7(4), pp. 49-65.
Friman, M., Fujii, S., Ettema, D., Gärling, T. and Olsson, L.E. (2011) 'Psychometric analysis of the satisfaction with travel scale', *9th Biannual conference of Environmental Psychology*. Eindhoven.
Fujii, S. and Kitamura, R. (2003) 'What does a one-month free bus ticket do to habitual drivers? An experimental analysis of habit and attitude change', *Transportation*, 30(1), pp. 81-95.
Gallego, F., Montero, J.-P. and Salas, C. (2013) 'The effect of transport policies on car use: Evidence from Latin American cities', *Journal of Public Economics*, 107(0), pp. 47-62.
Gatersleben, B., Murtagh, N. and White, E. (2013) 'Hoody, goody or buddy? How travel mode affects social perceptions in urban neighbourhoods', *Transportation Research Part F: Traffic Psychology and Behaviour*, 21(0), pp. 219-230.
González-Díaz, M. and Montoro-Sánchez, Á. (2011) 'Some lessons from incentive theory: Promoting quality in bus transport', *Transport Policy*, 18(2), pp. 299-306.
González-Gil, A., Palacin, R. and Batty, P. (2013) 'Sustainable urban rail systems: strategies and technologies for optimal management of regenerative braking energy', *Energy Conversion and Management* 75, pp. pp. 374-388.
González-Gil, A., Palacin, R., Batty, P. and Powell, J.P. (2014) 'A systems approach to reduce urban rail energy consumption', *Energy Conversion and Management*, 80(0), pp. 509-524.
Gould, J. and Zhou, J. (2010) 'Social Experiment to Encourage Drive-Alone Commuters to Try Transit', *Transportation Research Record*, 2144(1), pp. 93-101.
Government of South Australia (2009) *TravelSmart: Households in the West [Online]*. Australia. [Online]. Available at: http://dpti.sa.gov.au/__data/assets/pdf_file/0019/134290/TravelSMART_Households_in_the_West.pdf (Accessed: 29/11/2012).
Graham, D.J., Crotte, A. and Anderson, R.J. (2009) 'A dynamic panel analysis of urban metro demand', *Transportation Research Part E: Logistics and Transportation Review*, 45(5), pp. 787-794.
Graham, I. (2010) *The Global Economic Crisis - sectoral coverage. Automotive Industry: trends and reflections*. Geneva (Switzerland): International Labour Organisation.
Greater London Authority (2009) *Clearing the air: The Mayor's draft Air Quality Strategy for consultation with the London Assembly and functional bodies*. [Online]. Available at: http://legacy.london.gov.uk/mayor/environment/air_quality/docs/AQS09.pdf (Accessed: 10/04/2013).

Gripsrud, M. and Hjorthol, R. (2012) 'Working on the train: From 'dead time' to productive and vital time', *Transportation*, 39(5), pp. 941-956.
Guo, Z. and Wilson, N.H.M. (2011) 'Assessing the cost of transfer inconvenience in public transport systems: A case study of the London Underground', *Transportation Research Part A: Policy and Practice*, 45(2), pp. 91-104.
Haghshenas, H. and Vaziri, M. (2012) 'Urban sustainable transportation indicators for global comparison', *Ecological Indicators*, 15(1), pp. 115-121.
Hensher, D.A. and Li, Z. (2012) 'Ridership drivers of bus rapid transit systems', *Transportation*, 39(6), pp. 1209-1221.
Hensher, D.A., Stopher, P. and Bullock, P. (2003) 'Service quality—developing a service quality index in the provision of commercial bus contracts', *Transportation Research Part A: Policy and Practice*, 37(6), pp. 499-517.
Higgins, T. (1992) 'Parking taxes: Effectiveness, legality and implementation, some general considerations', *Transportation*, 19(3), pp. 221-230.
Hrelja, R., Isaksson, K. and Richardson, T. (2013) 'Choosing conflict on the road to sustainable mobility: A risky strategy for breaking path dependency in urban policy making', *Transportation Research Part A: Policy and Practice*, 49, pp. 195-205.
Ibeas, Á., Cordera, R., dell'Olio, L. and Moura, J.L. (2011) 'Modelling demand in restricted parking zones', *Transportation Research Part A: Policy and Practice*, 45(6), pp. 485-498.
IBM (2009) *IBM Brings 50% Reduction in Waiting Time to the Morning Commute in Sweden's Capital [Press Release]*. Available at: http://www-03.ibm.com/press/us/en/pressrelease/28463.wss (Accessed: 03/11/2013).
IEA & UIC (2013) *Railway Handbook 2013: Energy Consumption and CO2 Emissions*. Paris (France).
IPCC (2014) *Climate Change 2014: Mitigation of Climate Change. Working Group III Contribution to the IPCC 5th Assessment Report: Final Draft*. [Online]. Available at: http://report.mitigation2014.org/drafts/final-draft-postplenary/ipcc_wg3_ar5_final-draft_postplenary_full.pdf.
John, P. and Cole, A. (1999) 'Political leadership in the new urban governance: Britain and France compared', *Local Government Studies*, 25(4), pp. 98-115.
Kärrholm, M., Nylund, K. and Prieto de la Fuente, P. (2014) 'Spatial resilience and urban planning: Addressing the interdependence of urban retail areas', *Cities*, 36(0), pp. 121-130.
Kelly, A. and Clinch, P. (2006) 'Influence of varied parking tariffs on parking occupancy levels by trip purpose', *Transport Policy*, 13(6), pp. 487-495.
Koehler, L.A. and Kraus Jr, W. (2010) 'Simultaneous control of traffic lights and bus departure for priority operation', *Transportation Research Part C: Emerging Technologies*, 18(3), pp. 288-298.
Kottenhoff, K. and Brundell Freij, K. (2009) 'The role of public transport for feasibility and acceptability of congestion charging – The case of Stockholm', *Transportation Research Part A: Policy and Practice*, 43(3), pp. 297-305.
Lee, S.S. and Senior, M.L. (2013) 'Do light rail services discourage car ownership and use? Evidence from Census data for four English cities', *Journal of Transport Geography*, 29(0), pp. 11-23.
Leiserowitz, A., Maibach, E., Roser-Renouf, C. and Smith, N. (2010) *Climate change in the American Mind: Americans' global warming beliefs and attitudes in June 2010*. Conneticut: Yale University and George Mason University, N.H. [Online]. Available at: http://environment.yale.edu/climate-communication/files/ClimateBeliefsJune2010.pdf.
Lesteven, G. (2014) 'Behavioural responses to traffic congestion', *Transport Research Arena*. Paris, 14/04/2014-17/04/2014.
Litman, T. (2012) *Evaluating Public Transit Benefits and Costs: Best Practices Guidebook*. Institute, V.T.P. [Online]. Available at: http://cistup.iisc.ernet.in/Urban%20Mobility%208th%20March%202012/Evaluating%20Public%20Transport%20Benifits.pdf.

Litman, T. (2013) 'Comprehensive evaluation of energy conservation and emission reduction policies', *Transportation Research Part A: Policy and Practice*, 47(0), pp. 153-166.
Loader, C. and Stanley, J. (2009) 'Growing bus patronage and addressing transport disadvantage-The Melbourne experience', *Transport Policy*, 16(3), pp. 106-114.
Lorenzoni, I., Nicholson-Cole, S. and Whitmarsh, L. (2007) 'Barriers perceived to engaging with climate change among the UK public and their policy implications', *Global Environmental Change*, 17(3–4), pp. 445-459.
Lucas, K., Brooks, M., Darnton, A. and Jones, J.E. (2008) 'Promoting pro-environmental behaviour: existing evidence and policy implications', *Environmental Science and Policy*, 11(5), pp. 456-466.
Lucas, K. and Jones, P. (2012) 'Social impacts and equity issues in transport: An introduction', *Journal of Transport Geography*, 21, pp. 1-3.
Macário, R. and Jara-Diaz, S. (2008) 'Growing patronage: Challenges and what has been found to work', *Research in Transportation Economics*, 22(1), pp. 12-15.
Maibach, M., Schreyer, C., Sutter, D., van Essen, H.P., Boon, B.H., Smokers, R., Schroten, A., Doll, C., Pawlowska, B. and Bak, M. (2007) *Handbook on estimation of external costs in the transport sector*. Delft (The Netherlands).
Marsden, G. and King, S. (2009) 'Using deliberative methods to understand travel choices in context of climate change', *Transportation Research Record: Journal of the Transportation Research Board*, 2135, pp. 114-122.
Maslow, A.H. (1943) 'A theory of human motivation', *Psychological Review*, 50(4), pp. 370-396.
Milioti, C.P. and Karlaftis, M.G. (2014) 'Estimating multimodal public transport mode shares in Athens, Greece', *Journal of Transport Geography*, 34(0), pp. 88-95.
Mingardo, G. (2013) 'Transport and environmental effects of rail-based Park and Ride: evidence from the Netherlands', *Journal of Transport Geography*, 30(0), pp. 7-16.
Mobility Mixx (2013) *Mobility Mixx*. Available at: http://www.mobilitymixx.nl/ (Accessed: 15/11/2013).
MORI (2005) *Science in Society: Findings from Qualitative and Quantitative Research*. London: MORI. [Online]. Available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/260670/bis-05-1038-science-in-society-research.pdf (Accessed: 21/02/2013).
Moser, S.C. and Dilling, L. (2004) 'Making climate hot: Communicating the urgency and challenge of global climate change', *Environment*, 46(10), pp. 32-46.
Nykvist, B. and Whitmarsh, L. (2008) 'A multi-level analysis of sustainable mobility transitions: Niche development in the UK and Sweden', *Technological Forecasting and Social Change*, 75(9), pp. 1373-1387.
OECD (2010) *Reducing transport greenhouse gas emissions: Trends & Data 2010*. [Online]. Available at: http://www.internationaltransportforum.org/Pub/pdf/10GHGTrends.pdf.
Ogilvie, D., Egan, M., Hamilton, V. and Petticrew, M. (2004) 'Promoting walking and cycling as an alternative to using cars: Systematic review', *British Medical Journal*, 329(7469), pp. 763-766.
Outwater, M.L., Spitz, G., Lobb, J., Campbell, M., Sana, B., Pendyala, R. and Woodford, W. (2011) 'Characteristics of premium transit services that affect mode choice', *Transportation*, 38(4), pp. 605-623.
Özgür, Ö. (2011) 'Performance analysis of rail transit investments in Turkey: İstanbul, Ankara, İzmir and Bursa', *Transport Policy*, 18(1), pp. 147-155.
Passenger Focus (2012) *National Passenger Survey: Spring 2012 Main Report [Online]*. [Online]. Available at: http://www.passengerfocus.org.uk/research/publications/national-passenger-survey-spring-2012-main-report (Accessed: 10/09/2012).
Paulley, N., Balcombe, R., Mackett, R., Titheridge, H., Preston, J., Wardman, M., Shires, J. and White, P. (2006) 'The demand for public transport: The effects of fares, quality of service, income and car ownership', *Transport Policy*, 13(4), pp. 295-306.
Perone, J. and Volinski, J. (2003) *Fare, free or something in between?* Tampa, FL (USA).

Platt, R. and Retallack, S. (2009) *Consumer Power: How the Public Thinks Lower-carbon Behaviour could be Made Mainstream*. London: Research, I.f.P.P. [Online]. Available at: http://www.ippr.org/assets/media/images/media/files/publication/2011/05/consumer_power_1723.pdf.
Poortinga, W. and Pidgeon, N.F. (2003) 'Exploring the dimensionality of trust in risk regulation', *Risk Analysis*, 23(5), pp. 961-972.
Poudenx, P. (2008) 'The effect of transportation policies on energy consumption and greenhouse gas emission from urban passenger transportation', *Transportation Research Part A: Policy and Practice*, 42(6), pp. 901-909.
Rajan, S.C. (2006) 'Climate change dilemma: technology, social change or both? An examination of long-term transport policy choices in the United States', *Energy Policy*, 34(6), pp. 664-679.
Redman, L., Friman, M., Gärling, T. and Hartig, T. (2013) 'Quality attributes of public transport that attract car users: A research review', *Transport Policy*, 25(0), pp. 119-127.
Reis, V., Fabian Meier, J., Pace, G. and Palacin, R. (2013) 'Rail and multi-modal transport', *Research in Transportation Economics*, 41(1), pp. 17-30.
Rissel, C., Curac, N., Greenaway, M. and Bauman, A. (2012) 'Physical Activity Associated with Public Transport Use—A Review and Modelling of Potential Benefits', *International Journal of Environmental Research and Public Health*, 9(7), pp. 2454-2478.
Rodriguez, D.A. and Targa, F. (2004) 'Value of accessibility to Bogotá's bus rapid transit system', *Transport Reviews*, 24(5), pp. 587-610.
Rojo, M., Gonzalo-Orden, H., dell'Olio, L. and Ibeas, Á. (2012) 'Relationship between service quality and demand for inter-urban buses', *Transportation Research Part A: Policy and Practice*, 46(10), pp. 1716-1729.
Ronis, D.L., Yates, J.F. and Kirscht, J.P. (1989) 'Attitudes, decisions, and habits as determinants of repeated behavior', in *Attitude structure and finction*. Hillsdale - New Jersey,: Lawrence Erlbaum Associates, pp. 213-239.
Santos, G., Behrendt, H., Maconi, L., Shirvani, T. and Teytelboym, A. (2010a) 'Part I: Externalities and economic policies in road transport', *Research in Transportation Economics*, 28(1), pp. 2-45.
Santos, G., Behrendt, H. and Teytelboym, A. (2010b) 'Part II: Policy instruments for sustainable road transport', *Research in Transportation Economics*, 28(1), pp. 46-91.
Sastre, J., Sastre, A., Gamo, A.M. and Gaztelu, T. (2013) '"Economic Impact of Pedestrianisation in Historic Urban Centre, the Valdemoro Case – Study (Spain)"', *Procedia - Social and Behavioral Sciences*, 104(0), pp. 737-745.
Schlosser, N. (2013) 'Transit Systems get creative with revenue generation', *Metro Magazine*, 109(1), pp. 52-54.
Sharaby, N. and Shiftan, Y. (2012) 'The impact of fare integration on travel behavior and transit ridership', *Transport Policy*, 21(0), pp. 63-70.
Skalska, J., Krautscheid, T., Geißler, A. and Grotemeier, C. (2014) 'Why do travellers in Europe change transport mode? Facts and implications for policy and providers (project USEmobility) ', *Transport Research Arena*. Paris, France, 14/04/2014-17/04/2014.
Spence, A., Venables, D., Pidgeon, N., Poortinga, W. and Demski, C. (2010) *Public Perceptions of Climate Change and Energy Futures in Britain: Summary Findings of a Survey Conducted in January–March 2010 Technical Report (Understanding Risk Working Paper 10-01)*. Cardiff: Psychology, S.o. [Online]. Available at: http://www.ipsos-mori.com/Assets/Docs/Polls/climate-change-public-perceptions-of-climate-change-report.pdf (Accessed: 21/02/2013).
Stern, N. (2012) 'The UK Energy Bill: a good start, undermined by coalition politics', *Financial Times [Online]*edn), 30/11/2012 [Online] Available at: http://blogs.ft.com/the-a-list/2012/11/30/the-uk-energy-bill-a-good-start-undermined-by-coalition-politics/#axzz2LXJsmCsg (Accessed: 21/02/2013).
Stradling, S., Carreno, M., Rye, T. and Noble, A. (2007) 'Passenger perceptions and the ideal urban bus journey experience', *Transport Policy*, 14(4), pp. 283-292.

Sustrans (2009) *TravelSmart Project Review*. [Online]. Available at: http://www.eltis.org/docs/studies/TravelSmart_Project_Review_2009_FINAL.pdf (Accessed: 08/01/2013).
Tertoolen, G., van Kreveld, D. and Verstraten, B. (1998) 'Psychological resistance against attempts to reduce private car use', *Transportation Research Part A: Policy and Practice*, 32(3), pp. 171-181.
Thøgersen, J. (2009) 'Promoting public transport as a subscription service: Effects of a free month travel card', *Transport Policy*, 16(6), pp. 335-343.
Tirachini, A., Hensher, D.A. and Jara-Díaz, S.R. (2010) 'Comparing operator and users costs of light rail, heavy rail and bus rapid transit over a radial public transport network', *Research in Transportation Economics*, 29(1), pp. 231-242.
Tirachini, A., Hensher, D.A. and Rose, J.M. (2013) 'Crowding in public transport systems: Effects on users, operation and implications for the estimation of demand', *Transportation Research Part A: Policy and Practice*, 53, pp. 36-52.
Tonne, C., Beevers, S., Armstrong, B., Kelly, F. and Wilkinson, P. (2008) 'Air pollution and mortality benefits of the London Congestion Charge: spatial and socioeconomic inequalities', *Occupational and Environmental Medicine*, 65(9), pp. 620-627.
Transport for London (2004) *Impacts monitoring: Second Annual Report April 2004*. [Online]. Available at: http://www.tfl.gov.uk/assets/downloads/impacts-monitoring-report-2.pdf.
Transport for London (2006) *Impacts monitoring: Fourth Annual Report*. London: London, T.f.
Transport for London (2011a) *Travel in London: Report 4*. [Online]. Available at: http://www.tfl.gov.uk/assets/downloads/travel-in-london-report-4.pdf.
Transport for London (2011b) *Understanding the travel needs of London's diverse communities: A summary of existing research* London.
Tyrinopoulos, Y. and Antoniou, C. (2008) 'Public transit user satisfaction: Variability and policy implications', *Transport Policy*, 15(4), pp. 260-272.
UN (2007) *Realizing the Potential of Energy Efficiency: Targets, Policies, and Measures for G8 Countries. Expert Group on Energy Efficiency*. Washington DC: United Nations Foundation. [Online]. Available at: http://www.globalproblems-globalsolutions-files.org/unf_website/PDF/realizing_potential_energy_efficiency.pdf (Accessed: 20/10/2012).
UN (2008) *World Urbanization Prospects: The 2007 Revision*. New York: United Nations.
UN (2013a) *Human Development Report 2013 The Rise of the South: Human Progress in a Diverse World*. Available at: http://hdr.undp.org/en/media/HDR2013_EN_Summary.pdf (Accessed: 30/09/2013).
UN (2013b) *Planning and Design for Sustainable Urban Mobility: Global Report on Human Settlements 2013*. Abingdon (UK): United Nations.
Van Exel, N.J.A. and Rietveld, P. (2009) 'Could you also have made this trip by another mode? An investigation of perceived travel possibilities of car and train travellers on the main travel corridors to the city of Amsterdam, The Netherlands', *Transportation Research Part A: Policy and Practice*, 43(4), pp. 374-385.
van Goeverden, C., Rietveld, P., Koelemeijer, J. and Peeters, P. (2006) 'Subsidies in public transport', *European Transport*, (32), pp. 5-25.
Vergragt, P.J. and Brown, H.S. (2007) 'Sustainable mobility: from technological innovation to societal learning', *Journal of Cleaner Production*, 15(11–12), pp. 1104-1115.
Vigar, G., Shaw, A. and Swann, R. (2011) 'Selling sustainable mobility: The reporting of the Manchester Transport Innovation Fund bid in UK media', *Transport Policy*, 18(2), pp. 468-479.
Vredin Johansson, M., Heldt, T. and Johansson, P. (2006) 'The effects of attitudes and personality traits on mode choice', *Transportation Research Part A: Policy and Practice*, 40(6), pp. 507-525.
Wen, W. (2008) 'A dynamic and automatic traffic light control expert system for solving the road congestion problem', *Expert Systems with Applications*, 34(4), pp. 2370-2381.
Wener, R., Evans, G., Phillips, D. and Nadler, N. (2003) 'Running for the 7:45: The effects of public transit improvements on commuter stress', *Transportation*, 30(2), pp. 203-220.

Wener, R.E. and Evans, G.W. (2011) 'Comparing stress of car and train commuters', *Transportation Research Part F: Traffic Psychology and Behaviour*, 14(2), pp. 111-116.
Young, W. and Middlemiss, L. (2012) 'A rethink of how policy and social science approach changing individuals' actions on greenhouse gas emissions', *Energy Policy*, 41(0), pp. 742-747.