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An investigation into the feasibility and potential benefits of shared taxi services to commuter stations

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Parking is a serious problem at many rail stations where large numbers of commuters ‘park and ride’ mainly on a single occupancy basis. In many cases, these stations are not designed for mass parking, resulting in on-street parking conflicts with residents and local commercial businesses. Furthermore, congestion around stations is a growing problem, compounded by rail passengers being picked up by friends or relatives resulting in queues of waiting cars at station entrances. These ‘kiss and ride’ trips require double the fuel (home to station to home again) and impinge on the time of the driver providing the lift. In this paper, it is anticipated that the introduction of shared taxis to rail stations has the potential to relieve these parking and congestion problems while also providing an affordable extra service to the rail station for those without access to a car or other suitable public transport service. A model for shared taxi operation is presented and the potential viability and benefits of such a service is illustrated using data from two varied case study sites: (1) a station in South East England providing rail access to London and (2) a smaller station in Central Scotland providing rail access to Edinburgh.

Keywords: shared taxi; collective taxi; flexible transport service; commuter stations

1. Introduction

The objective of this work is to present the commercial opportunity for taxi operators to establish formal shared taxi services at commuter rail stations. It is argued that such services could be commercially viable for the taxi operator and will provide an affordable and attractive service for the user. For users without access to a car or other suitable public transport service, this will increase accessibility and opportunity for employment, while other benefits include relief of parking and congestion in the vicinity of the stations.

1.1. Shared taxis

Taxi sharing refers to the situation when more than one passenger undertaking separate trips jointly use the same vehicle for their journey (known as shared taxi or collective taxi). It excludes groups who are travelling together or ‘taxi-bus’ services which operate like a bus on a fixed route and timetable using a taxi vehicle. In general, taxi sharing provides the flexibility of a taxi at a lower cost to the user than that usually associated with taxi use. As Enoch (2005) reports, there are many examples of informal taxi

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sharing from less developed countries which are well used and are commercially viable to the operators, e.g. the Kombi shared taxis of Cape Town, South Africa; the Taxi Collectives of Havana, Cuba; the Dolmus of Istanbul, Turkey; the Taxi Train of Mauritius; Motorcycle taxis in Bangkok, Thailand and Rio de Janeiro, Brazil; and the Jeepneys of Manila, Philippines (see Enoch, Potter, Parkhurst, & Smith, 2004, for a more comprehensive review of these services).

Recently, there have been moves to 'formalise' several of these shared taxi services with greater regulation in order to improve safety, comfort and control, especially for those services acting as feeders to the mass transit network (e.g. Tangphaisankun, Nakamura, & Okamura, 2009; Wilkinson, 2008). However, lessons from the developed world have highlighted the risks to commercial viability of these services from increased regulation. Experiments with shared-ride taxis and jitney services in Seattle, San Diego, Indianapolis and several other US cities in the late 1970s and 1980s demonstrated that there is a market demand for frequent, on-call and sometimes door-to-door services that are cheaper than exclusive-ride taxis. However, Cervero (1996) reports that regulations governing urban transportation have been built up, layer by layer, over time to the point where today they represent significant obstacles to market penetration and service innovations. Entry and service restrictions are placed on taxis in most US cities, while jitneys, shared-ride taxis and most other for-profit ridesharing services have generally been regulated out of existence (Cervero, 1996).

In the developed world, there has more recently been a growing interest in the use of shared taxis as a lower operating cost alternative to bus-based flexible transport services (often referred to as 'demand responsive transport services'). Good examples of these include the RegioTaxi and TreinTaxi services in the Netherlands (MacDonald, 2008; Van Hamersveld, 2003), the Collecto shared taxi service in Brussels¹ and the Taxibus service in Rimouski, Quebec.² In the UK, the Commission for Integrated Transport (2008) presents the case for regional shared taxi provision in rural areas, but the UK Government has not taken up the recommendation to implement a large-scale region-wide shared taxi demonstration project. The institutional framework for shared transport services in the UK is described by Mulley (2010). Common to all the above shared taxi schemes is their reliance on significant subsidy funding from central or local government to sustain their operation.

There are few examples of formal shared taxi services operating on a commercial basis in more developed countries. Those that do exist generally serve as airport shuttle services (e.g. Perugia, 2004) or operate where a severe shortage in taxi supply exists, e.g. at Paddington Rail Station, London, where taxis serving pre-defined destination zones wait for a full complement of independent passengers all travelling to roughly the same destination – the shared service does not operate in reverse (i.e. from home to station), and in Washington DC during commuter hours when cabs are in short supply (see Cervero, 1996). A recent shared taxi experiment in New York³ has proved relatively unsuccessful with only the shared service to the airports and Port Authority bus terminal surviving with the other less-frequented routes discontinued.

In the UK, there have been some other attempts at offering shared taxi services from railway stations. These include services proposed in Swindon (to the west of London), Ipswich (to the north east of London) and at Marylebone and Kings Cross stations in central London. Enoch, Potter, Parkhurst, and Smith (2006) report that all of these initiatives failed but for a variety of reasons: the service in Swindon failed due to a hostile local authority and confusion over the licensing regime; the Ipswich service failed because of a lack of understanding about the scheme amongst the public and by the perceived low

probability of finding other passengers with whom to share; and the Marylebone and Kings Cross services failed due to a lack of concentrated demand. It is not clear why the Swindon local authority was opposed to the shared taxi scheme from Swindon station to one of the suburbs, especially as this required no financial support from the authority, there may have been conflicts of interest with incumbent bus operators, there may have been resistance from other taxi operators not involved in the scheme or it may simply have been uncertainty by the local authority of how such initiatives should be handled. What is clear from the lessons of failed schemes is that effective partnerships and understanding of the aims, operation, market potential and likely impacts are needed to reduce the risks of failure. Mulley, Nelson, Teal, Wright, and Daniels (2012) highlight the legislative complexities pertaining to flexible shared taxi provision and the barriers resulting from perceived or actual competition between flexible transport services including shared taxis and other modes of public transport. More recently, there has been an increased awareness of the potential applications and benefits of shared taxis amongst local authorities in the UK, in particular to complement rather than compete with existing commercial public transport provision. The Local Transport Act (2008) removes some of the legislative barriers to providing shared taxis while government guidance encourages the use of shared taxis (Department for Transport, 2010).

Commercial taxi share services brokered via the internet do exist but these tend to remain costly for the user and typically only provide transfers between city centre hotels and airports. One service named 'FairFare' did offer the possibility of shared rides to stations and seaports as well as airports but single occupancy fares applied unless a subsequent passenger used the site to book a similar trip at the same time. There was no formalised service provision or guaranteed shared ride fare to encourage regular uptake by users which would be required for a shared taxi commuter service. Due to low demand, the FairFare service has now closed.

Typically, shared taxi services providing daily or regular trips require a significant level of subsidy and generally provide for accessibility and social inclusion objectives rather than as commercially viable services (see Wright, Nelson, Cooper, & Murphy, 2009, for an evaluation of a subsidised rural shared taxi service and Mulley, 2010, for consideration of a national shared taxi scheme). There remains reluctance from taxi operators to offer non-subsidised shared services due to a perception that this will be less profitable than the current system due to limited levels of trade and there remains some confusion over the regulatory regimes in place and uncertainty over the ability to match passengers together to provide sensible shared trips.

2. Can we develop a commercially viable shared taxi service model?

From the above review, it is clear that in order for shared taxi services to be commercially viable, a careful design of services and fare structure is needed. The time of day, locations served and type of passenger targeted are crucial factors for success. In larger cities, there may be opportunities within the night-time economy to develop commercially viable shared taxi services but the passenger demands at this time are less regular or reliable and predictable, and there is also a greater reluctance to share with strangers. This paper argues that by concentrating on shared taxi services providing access to rail stations during commuter peaks, a commercially viable service can be delivered. The main reasoning for this is related to parking constraints at stations making the option of using shared taxis attractive to passengers and the demand for taxis exceeding supply in the morning and afternoon peak period making the offer of shared taxis attractive to taxi

providers. Added to this is the tendency for commuters to be prepared to pay higher fares (for reliable travel) than other users (Enoch et al., 2004) increasing further the potential for a commercially viable service.

2.1. *Parking constraints at rail stations*

Parking is a serious problem at many rail stations where large numbers of commuters 'park and ride'. In many cases, these stations are not designed for such activity. Stations used by the majority of commuters tend to be in or near the centre of small- to medium-sized towns where limited parking space is available and that which is available is often shared with residents and shoppers. As a result, on-street parking becomes a problem and lack of parking space during the day for shoppers impacts on commercial business in the area. The manifestation of this is that parking in and around satellite railway stations on commuter routes into large conurbations remains a real and growing problem. A report by Country Life⁴ investigated the scale of the station car parking problem within London's commuter catchment area. Interviews and surveys with estate agents, train operating companies and rail passenger organisations paint the picture of a lack of station parking capacity and long waiting lists for station parking spaces leading to overspill of day-long parking to surrounding residential streets creating conflict with local residents and worse congestion. This problem is not unique to the UK, similar issues are faced by New York commuters⁵ and it is common to large cities worldwide. Congestion around stations is compounded by rail passengers being picked up by friends or relatives resulting in queues of waiting cars at station entrances. These 'kiss and ride' trips are particularly costly to both the environment and the driver as the out and back trip (of home to station to home again) requires double the petrol, produces roughly twice as much pollution and impinges on the time of the driver making the pickup/drop-off.

It is anticipated that the introduction of shared taxis to rail stations used by 'park and ride' commuters has the potential to free up parking spaces for residents, shoppers and other train users travelling at off-peak times. The incentive for existing 'park and ride' commuters to use a shared taxi is based on the financial saving of parking charges which are often as high as £5 per day or £1200 per annum.⁶ Shared taxis can also be used by 'kiss and ride' commuters thereby reducing congestion and pollution, and by those without access to car or suitable public transport services thereby increasing accessibility and opportunity for employment to a large segment of the population. There is also the possibility of attracting latent demand from car users who currently drive all the way to work but may be inclined to use a shared taxi and train if such a service was available.

2.2. *Potential demand*

Rail passengers tend to arrive at and depart from train stations at similar times which mean that load factors for shared services at stations are likely to be better than load factors for shared services at other locations. During commuter peak periods, demand for taxis exceeds supply and is time limited, so any potential revenue from servicing this demand is lost for good if the supply is not sufficient. Increasing the number of taxi licences is one way to ensure the supply meets the demand but this creates surplus supply during the rest of the day, when demand is lower, which does not favour existing operators in any way since they get no more revenue during the peak and are faced with

more competition during periods of lower demand. The other way of increasing the supply to capture this unmet demand, without increasing competition in periods of low demand, is to offer taxi trips on a shared basis.

On the basis of the considerations outlined above, this paper argues that a shared taxi service serving commuter rail stations should be positioned and designed to attract a share of:

- (1) The existing demand:
 - (a) Park and ride commuters who would prefer to leave their car at home for their partner to use during the day but find the individual taxi too expensive and have no convenient bus service.
 - (b) Kiss and ride commuters who would prefer not to inconvenience their partner for a lift to and from station but find the individual taxi too expensive and have no convenient bus service.
- (2) The new and unmet demand:
 - (a) New rail users, with choices, looking for a flexible and secure means of accessing the station at a moderate and predictable price.
 - (b) The young + low-income groups and all those without access to a private car (for financial or health reasons) but find the individual taxi too expensive.
 - (c) Commuters who drive all the way to work rather than travel by train because access to, and parking at, local stations is a problem but find the individual taxi too expensive and have no convenient bus service.

3. Case study analysis

This section examines the potential viability and benefits of such a shared taxi service, illustrated using data from two varied case study sites: the first a station in South East England providing rail access to London (very large city, population 7 million); the second, a smaller station in Central Scotland providing rail access to Edinburgh (medium-sized city, population 500,000).

3.1. Case study 1: Harlow Town station

Harlow Town is a fairly typical commuter town with a population of 75,000 located 25 miles north of Central London. It has two rail stations and sits on the main rail corridor between Cambridge to London Liverpool Street with approximately two trains per hour stopping at Harlow Town station. It is also on the Stansted Airport to London Liverpool Street line with a further two trains per hour stopping. There are approximately 5100 single journeys per weekday from the station (or 2550 return journeys per day).⁷ There are at least 50 other commuter stations around London with similar levels of demand and frequency of train service to Harlow Town. Additionally, there are possibly over 100 more stations with lower demand and less frequent train services which still have station access and parking capacity issues.

The following analysis considers the design of a shared taxi service to Harlow Town station serving a catchment with 4 km radius around the station during the morning peak period between 06:45 and 08:15 h (journey time to central London is 45–55 min). The same service in reverse is to be provided in the evening peak period.

3.1.1. Potential users

We assume that the user base is to primarily come from the existing park and ride passengers.

Research conducted for Passenger Focus by Steer Davies Gleave (2006) examined parking capacity and utilisation at 101 stations in Greater Anglia region and conducted more detailed study at four stations including Harlow Town (Steer Davies Gleave, 2007). Harlow Town station car park was found to be at capacity with data showing average utilisation of the car park of between 91 and 99%. The research also included surveys related to method of reaching station and distance travelled to station. The information in Table 1 has been derived from this research. From this, we estimate that the number of park and ride passengers per train within 4 km of station (i.e. close enough to station to use shared taxi) is 46 (or 184 per hour).

3.1.2. Pricing

A key question is how do we make the service attractive to users? Consider a P + R commuter currently driving 4 km to a local rail station and then taking the train 40 km to work:

- Cost of car travel: £0.60 each way per day.⁸
- Cost of parking: £4 to £6 per day (parking costs £1000 to £1500 for season tickets at most London commuter stations).
- Total cost: £5.20 to £7.20 per day.

So, a shared taxi fare of around £3 each way could be charged for the same equivalent cost as park and ride commuters currently pay. For the first passenger picked up on a shared route, there will be an additional time in the vehicle incurred as the taxi picks up additional passenger(s). While this may add up to an additional 5 min on a journey which would take 10 min travelling directly, the time saved in not needing to find a parking space and then walking to/from the parking space to the station entrance is expected to balance this out. Taxis can drop off immediately adjacent to the station entrance.

3.1.3. Viability

Could this be commercially viable to a taxi operator?

- An average taxi trip of 4 km in Harlow pays £6.00⁹ and takes 20 min to pick up, drop off and return to station.¹⁰ At peak times for rail commuters, taxis can expect three passenger pickups per hour and £18/h in fares.

Table 1. Harlow Town station: estimated 'park and ride' demand.

Return trips per weekday	Proportion of commuter trips	Proportion of commuter trips which are 'park and ride'	Proportion of 'park and ride' trips originating within 4 km of station	Number of 'park and ride' commuters	Number of London bound trains in commuter period (06:45–08:15)	Number of 'park and ride' commuters per train
2550	48%	33%	80%	323	7	46

- If passengers are charged £3 for a 4 km trip on a shared basis and each taxi can undertake two shared journeys per hour, then they must attract three passengers per shared journey to match their earnings from individual hires. We assume only two shared rides per hour are possible as opposed to three individual rides per hour to account for the additional time required for drivers to deviate from the most direct route and to pick up or drop off the additional shared passenger(s).
- For a one-taxi operation, this would require only six P+R passengers per hour to switch to shared taxi service for the taxi operator to break even. This is only just over 3% of the P+R passengers who are close enough to the station to use a shared taxi.
- To ensure a reasonable profit for the taxi operator, at least four passengers per shared journey would be required. This would give a 33% increase in fare revenue over what they could expect with individual hires. This would only require 4.25% of P+R passengers within 4 km of the station to switch.
- To meet this, every train would require two taxis operating 15 min apart on half-hour cycles to the station. Even this would operate with a 33% profit with less than 10% of current P+R passengers (within 4 km of the station) switching to shared taxi.

It is thought likely that up to 10% of existing P+R passengers may choose to use a shared taxi service especially when the use of taxi would effectively be cost neutral. Based on this assessment, there is likely to be sufficient passengers interested in a shared taxi service to ensure commercial viability.

3.2. Case study: Livingston North station

Livingston is a town in Central Scotland with a population of 50,000 located 15 miles west of Edinburgh (population > 500,000). Until January 2011, Livingston North station provided rail services to Edinburgh two times per hour during the commuter peak with travel time of 27 min. Since Jan 2011, a previously closed section of railway infrastructure was reopened which provides a second rail corridor linking Scotland's two main cities of Edinburgh and Glasgow. Livingston North station is an intermediate point in this link and service frequencies to Edinburgh have increased to four per hour with travel times reducing to 22 min, while a totally new service now operates to Glasgow four times per hour with travel time of 48 min.

The 2010 daily boarding at Livingston North station was 942 passengers with 43% of these boardings (405) occurring in the morning peak between 07:00 and 09:00. The new line has been forecast to deliver additional 1600 passenger boardings per day (Jacobs, 2006). Assuming the new passengers forecast to use the station follow the same time distribution as currently, then there will be 688 (43% of 1600) new passengers accessing the station between 07:00 and 09:00. Prior to the new line opening, there was a car park capacity of 310 spaces at Livingston North station. Evidence from SESTRAN Integrated Transport Corridor Studies indicated that parking demand outstripped supply by some margin at Livingston North station and that there was likely to be latent demand for train use in this area. With the opening of the new line, an additional 12 car park spaces have been provided.

The following analysis considers the design of a shared taxi service to Livingston North station serving a catchment with 3 miles radius around the station during the morning peak period between 07:00 and 09:00 h (journey time to Edinburgh 22–27 min). The same service in reverse is to be provided in the evening peak period.

3.2.1. *Potential users*

We assume that the user base is to primarily come from the existing park and ride passengers.

Data from the National Rail Travel Survey (see NRTS, 2010) on mode of access to Livingston North station have been obtained from Transport Scotland. The information in Table 2 has been derived from this data and indicates that the number of park and ride passengers per train within 4.8 km of the station (i.e. close enough to station to use a shared taxi) is equal to 17 (or 69 per hour).

3.2.2. *Pricing*

How do we make the service attractive to users?

Consider a ‘P + R’ commuter currently driving 4.8 km to the local rail station and then taking the train 15 miles to work.

- Cost of car travel: £0.8 each way per day.
- Cost of parking: £0 per day (there is currently no charge for parking at Livingston North station).
- Total cost: £1.60 per day.

If a shared taxi fare of £3 each way is charged, this will represent a £4.40 per day increase in cost to the user. This is not as attractive a proposition to the user as the Harlow Town case.

3.2.3. *Viability*

Could this be commercially viable to a taxi operator?

- Taxis in the Livingston area can typically expect to earn £18–£20 per hour in the a.m. peak hours (based on information provided by personal contact with local taxi suppliers ‘Calder cabs’).

Table 2. Livingston North station: estimated ‘park and ride’ demand.

Return trips per weekday	Proportion commuter trips	Proportion of trips which are ‘park and ride’	Proportion of ‘park and ride’ trips originating within 4.8 km of station	Number of ‘park and ride’ commuters	Number of trains in commuter period (07:00–09:00)	Number of ‘park and ride’ commuters per train
942	43%	41%	83%	138	8	17

- If passengers are charged £3 for up to 3 mile trip on a shared basis, and each taxi can undertake two shared journeys per hour, then they must attract 3.5 passengers per shared journey to match their earnings from individual hires.
- For a one-taxi operation, this would require seven P+R passengers per hour to switch to shared taxi service for the taxi operator to break even. This is 10% of existing P+R passengers (who are close enough to the station to use a shared taxi).
- To ensure a reasonable profit for the taxi operator, at least 4.5 passengers per shared journey would be required. This would give a 35% increase in fare revenue over what they could expect with individual hires. This would only require 13% of existing P+R passengers within 3 miles of the station to switch.
- To meet this, every train would require two taxis operating 15 min apart on half-hour cycles to the station. This would operate with a 35% profit with 26% of current P+R passengers (within 3 miles of the station) switching to shared taxi.

Attracting 26% of existing park and ride users is thought to be unlikely. It may be possible that up to 10% of existing park and ride passengers would opt to use a well-designed shared taxi service, however, the additional cost of £4 per day of using the shared taxi for these passengers will deter many of these potential users, and so attracting even 10% of existing P+R customers may be ambitious. Therefore, based on existing passengers at Livingston North, a service designed to meet every train is not thought to be viable and it is even questionable whether a service which meets every other train (i.e. two trains per hour) could be viable.

Factoring in the potential users of the shared taxi generated from the forecast rail passengers following opening of the new line gives the results in Table 3. Once these station forecast demand figures are reached, there would be a total of 184 potential park and ride passengers per hour. If the shared taxi service was then designed to meet every train, to generate a 35% profit would require attracting 18 passengers per hour which represents less than 10% of these potential park and ride passengers. As parking space is already at capacity, a shared taxi service could expect to attract a significant proportion of new users who would otherwise choose to park and ride. A shared taxi service designed to only meet every other train would require less than 5% of the potential park and ride passengers to provide a 35% profit. This is thought to be very plausible.

Based on this demand assessment, there is only likely to be sufficient passengers interested in a shared taxi service to ensure commercial viability once the forecast new passenger demands resulting from the opening of the new line are established.

Table 3. Livingston North station: additional forecast 'park and ride' demand.

Return trips per weekday	Proportion commuter trips	Proportion of commuter trips which are 'park and ride'	Proportion of 'park and ride' trips originating within 4.8 km of station	Number of 'park and ride' commuters	Number of trains in commuter period (07:00–09:00)	Number of 'park and ride' commuters per train
1600	43%	41%	83%	234	8	29

4. Discussion

The above analysis suggests the service design which is likely to produce a commercially viable shared taxi service at two differing commuter railway stations in the UK. Clearly, in addition to the potential P+R passengers considered in the analysis, there are also other potential passengers: kiss and ride passengers and commuters who currently drive the full journey to work because of a lack of parking at the station. The immediate financial incentive for these passengers is not as strong in the Harlow Town case as they do not currently pay for expensive station parking. However, the following advantages exist:

- A commuter currently driving 45 km to work and paying £0 parking will pay around £10 per day in fuel costs. A train season ticket for the same journey works out at about the same. However, the train is significantly quicker due to congestion on the roads (up to an hour faster). To some commuters, the time savings will outweigh the extra £3 each way shared taxi fare.
- For the kiss and ride passengers, the time savings and advantage to partners of not being inconvenienced by taking time to drop off at station and the additional advantage of having the car at home for them to use during the day may outweigh the additional shared taxi cost incurred.

At Harlow Town, 24% of commuter trips are kiss and ride (K+R) and three quarters of these originate within 4 km of the station = 224 return trips/day or 32 passengers per train. This provides a significant additional user base for the service to draw on. At Livingston North, kiss and ride passengers are currently negligible although this is likely to change as the forecast increases in rail passenger numbers take effect.

Other beneficiaries of a shared taxi service to commuter stations include:

- Local business who benefit through release of central parking spaces for town shoppers.
- Train operators benefit through extra passenger revenue.
- Environmental benefits – less traffic on motorways and local town roads.
- Car available for use by partner (possible impact on ownership of second cars).
- All those without access to a private car (for financial or health reasons) have a more affordable means of accessing the rail station, particularly beneficial for wider access to job opportunities.

The analysis conducted in this paper is based on establishing potential users of the shared taxi service based on data related to rail passenger numbers, mode of travel to station and distance from station. The results present the proportion of existing park and ride passengers required to switch to shared taxi to ensure a commercially viable service.

What the analysis has not considered is the commuter acceptance of using such a shared taxi service. Gender is known to be a barrier to sharing rides with unknown strangers in the liftsharing/ridesharing domain (see Siddiqi, 2012). While this still remains a barrier to some in a taxi-sharing setting, it is less so since there is always a third person (the driver) present. This reduces female insecurities of sharing rides with unknown males (Sun, Golightly, Sharples, & Bedwell, 2012). Previous research has also shown that comfort with sharing a taxi was largely contingent on the fellow passenger's

membership in a common group (Redmiles, 2013; Sun et al., 2012). While the shared taxi service outlined in this paper brings together previously unconnected individuals, use of the service could be membership-based, only requiring an initial registration. One approach to build trust between unacquainted taxi sharing partners is through systems that help establish a participant's reputation. Examples of this are common in ride-matching systems where individual's details are accessed from social networking sites allowing users to obtain more background information of potential drivers and passengers (see Chaube, Kavanaugh, & Perez-Quinones, 2010).

Further investigation on commuter's willingness to pay and sensitivity to price will need to be researched to establish the optimal fare. There has been little work done in this area in the UK, but a recent study in Cambridge looked at user attitudes to shared taxi schemes conducting 582 on-street public interview surveys (Halcrow Group Ltd, 2011). When asked what if anything would make them consider sharing a taxi with strangers, the majority of respondents (94.2%) stated they would share a taxi in order to save money; 48.5% of respondents stated they would use a shared taxi service if they only had to pay half of the fare and 65.5% would use it if they only pay a quarter of the fare. The average fare respondents would be prepared to pay for a two mile journey was £2.84. Looking at the purpose for which they would consider using a shared taxi service, 61.5% stated they would use it for commuting and 78.5% would use a shared taxi service in order to connect with other transport, e.g. access to the rail station. Although this is only one study, it does reveal an interest in use of shared taxis to rail stations at the right price. What is known from other failed shared taxi services is that a simple to understand fare structure is essential and there needs to be a guaranteed fixed fare regardless of number of shared users. Obviously, if fixed shared fares are offered to passengers regardless of the number of passengers carried, then the operator is exposed to some risk.

There are also passenger concerns over the reliability of shared taxi services. There is the risk that the taxi does not pick up in time for the outward train connection. Work by Enoch et al. (2004) identified that the factor most highly rated by commuters using flexible transport services is certainty of arrival time. The importance of reliability concerns will be linked to frequency of trains. If the intended train is missed, then a wait of 15 min for the next train may be acceptable to most users. However, if the wait is 30 min or more, then the reliability of the shared taxi becomes paramount.

Commuters also desire the flexibility to easily alter booked taxi pickup times, for instance, if delayed at work. The use of technology to enable simple alterations using mobile devices and receiving confirmation of changes facilitates this. When delays are experienced, real-time updates on taxi locations and adjusted pickup times can also be sent to commuters mobile devices providing extra assurance on service reliability.

Concern about engaging in anti-competitive activities may exist with certain shared taxi services. It is important to position the shared taxi service as clearly distinct from both public transport and taxis, in order to avoid (real and perceived) competition. The service should be designed to primarily target a new market of taxi users: those journeys currently made by private car (park and ride, and kiss and ride); latent demand trips that would otherwise not be made due to cost or lack of provision; and new trips from new rail users resulting from improved rail service. There may be some unavoidable abstraction from existing individual taxi use, however, it is expected that this will be limited as individual taxis are too expensive for most commuters (e.g. in Livingston North station, only 1% of passengers access the station during the morning peak by individual taxi). Where bus services to the station exist, shared taxi fares should be set higher than an

equivalent bus ticket for similar distance in order to minimise abstraction from existing bus use.

A major barrier to the introduction of shared taxi services has been the fact that many commuter rail services are operating at or close to capacity during the peak periods, thereby limiting the demand for taxi rides from new rail users. This needs to be considered if designing such services. The Harlow Town case study featured in this paper is on a commuter corridor which is approaching capacity in peak periods. Current plans to increase the capacity of the rail services serving Harlow Town station include the introduction of new rolling stock with designs offering much greater standing such as the Class 378 Units (resulting in capacity increases of up to 50% on existing services). However, there are no plans to increase the parking capacity at the stations. This further enhances the need for and potential viability of such a shared taxi service.

To date, in the UK, there has been very little attempt made by taxi operators to combine unconnected individual passenger journeys in the same taxi. This is primarily down to three reasons:

- there is a perception amongst taxi operators that shared taxi services might be less profitable than the current system due to limited level of trade;
- taxi operators have very limited means of identifying potential passengers with similar trip requirements (time and direction of trip);
- potential passengers can't find information on taxis offering shared trips or other passengers wanting to share a trip in the direction in which they are travelling at the time they are travelling.

New technology applications are providing solutions to these problems. These include smart phone applications such as <http://taxisharechicago.com/>, <http://www.cabcorner.com/>, <http://taxifortwo.co.uk/about>, <http://sharethefare.com.au/>, etc. These bring together trip requests from disparate individuals (or individuals from a controlled group) wanting to share taxis. Features include one-click ride requests, fare calculations, identification by photo or apparel, Paypal integration and a comprehensive feedback/rating system. While these bring together passengers with similar journey demands, the onus is on the passengers to agree their shared rides prior to booking a taxi. Taxi booking systems which accept booking requests from individual users and then aggregate them into shared rides are now emerging. The matching software and features for these are not radically different to those listed above but their effectiveness does require more careful planning of the taxi services in order to maximise the probability of finding suitable sharers. The reason for this is that using taxi sharing apps where the onus is on the passengers to agree their shared rides prior to booking a taxi allows for negotiation between passengers to find mutually acceptable times etc. When accepting booking requests for shared rides prior to matching passengers, the ability to negotiate is lost. Hence, to maximise the chance of a successful match requires more structure to the rides on offer. This fits well with the concept of offering shared taxis meeting specific timetabled trains at specific station locations discussed in this paper. Taxi-sharing software provider Bandwagon (<http://bandwagon.io/>) follows this approach for taxi passengers travelling to and from New York's LaGuardia airport and have identified rail stations as another potential market opportunity. A new shared taxi service has also recently been launched (November 2013) in Montreal called Everyday (<http://everyd.org>) using the Bandwagon technology. The matching software is accessible from a web platform and on smartphones which allow users to post their departure point, their destination and the desired date and time. Once the search is

launched, users will have a choice among the following three options: Only Share, Prefer Share and Solo. In all three cases, the cost of the ride will be posted beforehand. Matches will be carried out electronically. If a user's ride is matched, an e-mail will be sent to the user confirming the match. They will then be able to accept or refuse the taxi ride. If the user chooses 'prefer share', the status of their ride can subsequently change, and their fare be adjusted, if a match is made between initial booking and time of travel. While such systems help match passengers wishing to share rides, their effectiveness is limited to some extent by their inability to negotiate the terms of the initial booking request to attain compromised yet still acceptable matches. Future versions of these shared booking apps are likely to incorporate automated negotiation functions (see Emele et al., *in press*).

5. Conclusions

There are very few examples of commercially viable shared taxi services outside airport feeders. This paper presents a model of shared taxi provision to commuter rail stations and through analysis of data from two contrasting commuter stations in the UK, assesses the level of take-up from existing park and ride rail passengers to ensure a commercially viable service.

This analysis shows that commercially viable shared taxi services could be achieved by attracting between 5 and 10% of existing park and ride users. The combination of station parking difficulties and high parking charges make this level of take-up more likely.

The discussion highlights both passenger and service provider barriers and concerns over shared taxi use but identifies that the emergence of new technologies are offering solutions to many of these problems.

However, the need still exists for further evidence on appetite for such services amongst passengers and providers alike, and suggested further work should include a real demonstration of a shared taxi scheme to a commuter station supported by surveys with commuter rail passengers to fully assess likely take-up and commercial viability of such services.

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Notes

1. <http://www.urbanicity.org/Site/Articles/Dufour.aspx>
2. http://www.tc.gc.ca/media/documents/programs/cs06e_taxibus.pdf
3. <http://www.nytimes.com/2010/02/22/nyregion/22taxi.html>
4. http://www.countrylife.co.uk/property_news/article/57852/Commuters-Car-Parks.html
5. http://www.nytimes.com/2004/08/01/nyregion/commuter-s-sentence.html?ref=parking&page_wanted=1
6. <http://www.bbc.co.uk/news/business-12252538>
7. Derived from Station Usage data for 2009–2010 obtained from the Office of Rail Regulation (<http://www.rail-reg.gov.uk/server/show/nav.1529>).
8. Based on Google Maps estimated fuel costs for a range of journeys up to 4 km from Harlow Town Station. These varied between £0.5 and £0.7 each way.
9. <http://www.harlow.gov.uk/pdf/aHackney%20Carriage%20Tariffs%20-%20Appendix%20B.pdf>
10. Derived from Google Maps travel time calculator.

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