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REPORT

CROSSROADS

CHOOSING A FUTURE FOR LONDON'S TRANSPORT IN THE DIGITAL AGE

Laurie Laybourn-Langton

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Institute for Public Policy Research

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CONTENTS

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SUMMARY

60-SECOND SUMMARY

While London's road transport is of foundational importance to the city's communities and economies, it causes a number of major problems. In 2010, the equivalent of 9,416 deaths were attributed to air pollution, and congestion exacted an estimated economic cost of £5.5 billion. This is the result of the type of transport modes available to Londoners, how they are used, and the systems that determine transport priorities. As such, one of the primary methods of reducing transport-related problems in London is the unprecedented modal shift towards more sustainable forms of transport that has occurred over the last decade or so.

In that time, digital technology has enabled the development of new transport services, including journey planners, car clubs and on-demand private hire. These new mobility services could interact within London's transport system to deliver positive network effects, including complementing efforts to enable more public and active transport, and so allow for an unprecedented opportunity to overcome negative outcomes, such as air pollution and congestion, and to improve the city's spaces and Londoners' lives. Evidence suggests that some of these services are already having a tangible positive effect, as, for example, is the case of car clubs, which are unlocking more sustainable travelling behaviours. Conversely, concerns exist over the potential for negative network effects that undermine the ongoing move toward more sustainable behaviour.

London is at a tipping point and needs to decide how to react to these changes. Indeed, the pace and reach of technological change is such that a window of opportunity currently exists in which action can be taken by London's government to ensure the positive potential of these services is realised. The chance of negative path dependency is intolerably high without action in this term. As such, the mayor should incorporate a vision for new transport technologies into the *Mayor's Transport Strategy* in which shared transport and digital technology realise their potential to drive positive transport outcomes. This vision should be defined by a clear set of objectives for London's overall transport network and include a framework through which this vision can be achieved. In doing so, he is offered a unique opportunity to formulate London's, and the UK's, role in responding to the digital revolution and realising the socioeconomic opportunities it affords.

KEY FINDINGS

- Road transport is the leading cause of a number of problems in London. These include air pollution, congestion, and the large opportunity cost in forgone spatial opportunities.

- The mayor of London and Transport for London (TfL) are seeking to affect a modal shift towards more sustainable forms of transport behaviour. This modal shift is occurring, with a 10.4 per cent net mode shift from private to public and active transport between 2000–2015. Public and active transport now account for about 64 per cent of all one-way commuter movements in London.
- Meanwhile, digital technology has enabled the rise of new models of personal transport services that help travellers to move from ownership of vehicles to their use as a service, including journey planners, car clubs, on-demand private hire, and other shared modes.
- New mobility solutions could help or hinder efforts to effect more sustainable forms of travel behaviour and are already having a tangible impact on London's transport system. Evidence suggests that, in the case of car clubs, for example, membership unlocks positive behaviour change, lowering car use, crowding in higher public and active transport use, and driving the uptake of cleaner vehicles.
- The potential positive benefits of effectively incorporating these services into transport networks are profound, but require the definition of those key objectives they should seek to meet, and the public policy framework through which public and private bodies can achieve them.

RECOMMENDATIONS

- The mayor of London should incorporate a vision and framework for new transport technologies into the *Mayor's Transport Strategy* in which shared transport and digital technology are able to realise their potential in driving positive transport outcomes. This framework should include:
  - An urgent audit of new mobility markets and their potential and future effects upon key transport-related outcomes.
  - A set of overall positive outcomes for London's transport system, and how each new service and mode can contribute to support the uptake of more sustainable travel behaviours.
  - The rapid development of an explicit framework for new mobility markets, in collaboration with operators of new mobility services.
  - The provision of guidelines for public bodies and private operators on how to best gain from new mobility markets and work within the new market framework.
- Car clubs should be a key part of the mayor's vision for London's transport system and so the Mayor's Transport Strategy should include measures for how car clubs can help achieve key transport objectives.
- TfL and boroughs should work with operators to develop borough-by-borough agreements to enable car club development.
- TfL should become the central intermediary for mobility data in London, acting as a neutral, third-party platform through which data is collated and equal access by all mobility operators is guaranteed.

- TfL should assess the potential for a mobility as a service (MaaS) platform market in London and develop recommendations for policy responses, including a market framework and the feasibility of a TfL MaaS platform.
- The mayor should mandate TfL to investigate the potential for a smart charging system and an integrated road pricing scheme in London.
- The mayor should introduce a new market framework for EV charging networks in London, including regulation to ensure their proper functionality, ubiquity, interoperability and fair access to mobility operators and users.
- The mayor should appoint a chief digital officer for London.

1. INTRODUCTION

London is adversely affected by an array of problems caused by its transport. These include air pollution, to which the equivalent of 9,416 deaths were attributed in 2010 (Walton et al 2015), and congestion, which exacted an economic cost of £5.5 billion in 2014/15 (TfL 2015a). In seeking to reduce these negative outcomes, successive mayoral administrations have sought to drive a modal shift towards more sustainable transport behaviours; from private cars to public and active transport, such as cycling and walking. They are succeeding; between 2000 and 2015 there was a 10.4 per cent net mode shift from private to public and active transport, which now account for about 64 per cent of all one-way commuter movements in London (TfL 2016a).

However, negative transport-related problems are still set to increase, in the case of congestion, and are highly entrenched, as with the air pollution problem. In turn, London has seen its position in liveability rankings drop behind major global cities, such as Berlin and Paris, who are taking advanced action to minimise air pollution and congestion (Collinson 2016). To make matters worse, London's population is forecast to grow from around 8.5 million to over 10 million by 2031, accelerating already increasing demand for journeys, transport options and constrained road space (GLA 2014).

London is also having to grapple with the effects of disruptive technologies on incumbent transport markets, and is on the cusp of major changes to the way people move around the city. Digital technology has enabled the development of new transport services, including journey planners, car clubs and on-demand private hire. However, concerns exist as to the impact of these technologies on transport outcomes in London, with, for example, the emergence of private hire platforms and their net effect on congestion and air pollution (LATC 2017).

This report explores the effects that these changes are having now and could have in the future. It argues that technological developments in transport could complement existing transport policy, and that positive network effects between new and existing transport services could create an unprecedented ability to overcome London's transport difficulties, providing the mayor with profound scope to improve the city's spaces and Londoners' lives.

This report's central conclusion is that public intervention is required to realise these ends, and that a window of opportunity currently exists in which action can and must be taken by London's government. When this window closes, it will markedly increase the possibility of a negative path dependence upon which new technologies will exacerbate existing problems, and create new ones. The mayor of London should act now to provide a vision and set of objectives that lays out how new services can

realise their potential to form a positive part of London's transport system, and provide the market framework through which this can be achieved.

In chapter 2, we start by exploring the array of transport-related problems in London and existing efforts to combat them. Chapter 3 reviews emergent technologies in transport and their effect on travel behaviours, and explores the potential positive and network effects of these technologies. Chapter 4 then provides a number of policy responses the mayor can take this term that could increase the chance of realising positive – and avoiding negative – network effects. Chapter 5 concludes.

This report is the outcome of an extensive research process, including workshops, surveys and interviews, which drew on the input of a broad range of key stakeholders from across the public, private and third sectors.

2. LONDON'S TRANSPORT PROBLEMS AND EFFORTS TO COMBAT THEM

The ability for people and goods to move around London is of foundational importance to its many communities and economies. This ability is determined by the modes of transport available to commuters and businesses. In turn, the volume and movements of these modes, their cost and degrees of physical accessibility, and their environmental, spatial and public health impact, are a major influence on the socioeconomic makeup of the capital. As such, transport markets, the infrastructure that enables them, and the interventions of public bodies and private firms are some of the most important factors shaping London's development.[1]

2.1 TRANSPORT-RELATED PROBLEMS IN LONDON

London's transport is responsible for – or at least significantly contributes to – major problems in the capital. These include the by-products of unsustainable vehicle fuels, such as air pollution; the public health impact of forgone physical activity; and the inefficient use of urban space by congested roads. Below, we inspect some of these problems.

Air pollution

London is suffering from a persistent air pollution problem. The total mortality burden in 2010 of two air pollutants, particulate matter (PM2.5) and nitrogen dioxide (NO_2), is estimated to have been up to 140,734 life-years lost, or the equivalent of up to 9,416 deaths (Walton et al 2015).[2] In all, these health effects imposed an estimated economic cost of between £1.4 billion and £3.7 billion (ibid). This is a result of London's failure to meet both European Commission and World Health Organisation (WHO) guidelines on NO_2 concentrations, and WHO guidelines on PM concentrations. In 2017, for example, London breached its annual air pollution limit within five days of the new year (Carrington 2017).

The greatest source of air pollution in London is road transport, which is responsible for nearly half of both nitrogen oxide (NO_x) and PM emissions across both Greater and Central London (GLA 2010a). Indeed, the greatest single contributor to air pollution is the diesel

1 Personal and commuter travel are the primary focus of this report, as it is arguably within these areas that greatest disruption from digital technology has occurred, though we recognise the central role of commercial transport in London's transport system and the high levels of disruption it is experiencing. It is IPPR's intention to extend its research programme into this area.

2 However, it was noted by the study's authors that some of this effect may be due to other traffic pollutants.

engine, causing around 40 per cent of NO_x emission across the whole of the city, with a broadly similar proportion for PM10 (LAEC 2015).

The adverse effects of this pollution fall disproportionately on children, and on ethnic minority and deprived communities (Howard 2015, Vaughan 2016). Lower quality of life has undermined London's standing in the world, with recent rankings putting the capital below other European cities in terms of liveability (AMEC 2014). The growing understanding of air pollution's impact on health has seen it rise up the political agenda, and the mayor of London is consulting on measures to drive towards more rapid compliance with legal limits. Ultimately, the road transport air pollution problem is so entrenched it will likely take a large net reduction in vehicle miles and thus require the phase-out of diesel and petrol vehicles across large parts of inner London (Laybourn-Langton et al 2016).

Congestion

Traffic congestion is both the cause and effect of the inefficient use of roads; it increases air pollution, leads to longer journey times, and creates direct and indirect economic costs (LATC 2017). In London, the average vehicle speed on major roads is falling, from 19.9 miles per hour (mph) in 2012/13 to 17.7 mph in 2015/16 (TfL 2016b). Across London, the time lost to delays increased by 14 per cent between 2012/13 and 2014/15, and the excess time waiting for a bus over its scheduled time increased by 20 per cent, driving a fall in bus ridership (LATC 2017).

The economic costs of this congestion have increased by 30 per cent between 2012/13 and 2014/15, from £4.2 billion to £5.5 billion (TfL 2016c). These costs are greater outside of central London, with congestion costing £3.6 billion in outer London, £1.3 billion in inner London and £0.6 billion in central London in 2014/15. The city's increasing population could mean that the transport system will have to cater for 5 million extra journeys per day by 2030, in addition to the 26 million existing daily journeys (TfL 2017a). It is unlikely that London's road network would be able to support such an increase in journey volume, and some estimates put the cost of congestion by 2030 at over £10 billion (CEBR 2014).

Congestion is the result of traffic volumes demanding spatial capacity greater than that available. Counterintuitively, traffic volumes in London have been decreasing over the last 15 years, and were 10 per cent lower in 2015 than in 2000 (TfL 2016a). This was the result of a modal shift away from private vehicle use; economic fluctuations; road capacity changes, including reallocation of road space to improve facilities for pedestrians, cyclists and taxis; and temporary construction work (TfL 2017b). However, these measures have also reduced road capacity, leading to a net increase in congestion. Furthermore, traffic volumes are on the rise again, which will have 'significant implications for the management of the road network in the coming years' (TfL 2015c). The LATC have also highlighted the growth of PHVs and on-demand delivery as playing a major role in this increase in traffic volume and called for more action on congestion reduction (LATC 2017).

Carbon emissions

Around 22 per cent of London's CO_2 emissions come from transport (GLA 2015a). Transport's contribution to London's emissions has been growing, and are set to rise by 4 per cent to 26 per cent of emissions by 2020 (TfL 2015b). Within this, road usage makes up 73 per cent of total transport emissions (GLA 2015a), resulting from a high prevalence of petrol and diesel cars and heavy vehicles. Indeed, diesel vehicles were promoted over petrol by the last Labour government through tax incentives in an effort to reduce CO_2 emissions in order to tackle climate change. However, the CO_2 fuel efficiency gap between diesel and petrol is no longer apparent (EEA 2016), while their major contribution to air pollution has become clear, as noted above.

Other public health effects and spatial considerations

Alongside the health consequences of air pollution and those arising indirectly from climate change, road vehicles can also lead to negative health outcomes through road danger, the opportunity cost of foregoing physical exertion, and the loss of socioeconomic opportunities through poor physical accessibility, among others (TfL 2016a).

- **Road safety:** since 2000, London's road safety has improved considerably, with road deaths and serious injuries decreasing by 66 per cent between 2000 and 2015 (TfL 2016a). However, vulnerable road users, including pedestrians and cyclists, still remain at risk, accounting for 79 per cent of deaths or serious injuries.
- **Physical activity:** 66 per cent of adults in London do not meet the recommended minimum target of 150 minutes of physical activity per week (TfL 2016a). In fact, around 28 per cent of adults in London do not even perform 30 minutes of activity over the week.
- **Lack of physical accessibility:** while physical accessibility to public transport has improved since 2000, around 40 per cent of the network was still without full accessibility in 2015 (TfL 2016a). Meanwhile, the average trips per day for disabled people in London is 34 per cent lower than for those without disabilities.

Transport is also a major determinant of **urban development outcomes**. London has an annual new homes requirement of around 50,000, but has been building at half that rate (LHC 2016). Those areas with greatest capacity for development are also those with the poorest transport connectivity, stultifying private sector investment. As such, the mayor of London has recognised the role that transport can play in enabling housing development (GLA 2016a). Furthermore, higher density development is both enabled by transport connectivity and enables lower car ownership, higher levels of active transport, lower trip rates and healthier and more sustainable communities (GLA 2014).

Finally, road transport is also a **major determinant of how space is used** in the city and, often, this use is highly inefficient. It is estimated that, on average, vehicles are parked for around 97 per cent of the time (Bates and Leibling 2011), and that the average occupancy rate of a private car in London is 1.6 people per journey (TfL 2015d). This level of underutilisation increases the amount of land given away to vehicles, imposing a large opportunity cost in foregoing alternative spatial opportunities, which could include contributing to positive health and socioeconomic outcomes, such

as walkways, parks and other public spaces (Arup 2016). This has led the mayor to put the concept of 'healthy streets' at the core of his strategy for London, in which public health is enhanced by the improvement of London's urban realm and the encouragement of active and public transport behaviours (GLA 2016a).

2.2 TRANSPORT POLICY IN LONDON

TfL and successive mayoral administrations have introduced policies to combat transport-related problems. They aim to achieve:

- a reduction in the number of vehicles on London's roads – for example, the Congestion Charge Zone (CCZ), which charges vehicles to enter central London in an effort to reduce congestion
- greater spatial efficiency on roads, both in terms of vehicle movements and the use of space in vehicles – for example, encouraging bus use, as buses can transport higher numbers of people per unit volume than private cars
- phasing out unsustainable fuels from the aggregate transport fuel mix – for example, the proposed ultra low emissions zone (ULEZ), which will charge vehicles below certain pollution standards
- providing increased socioeconomic and physical accessibility to transport options – for example, discounts for tube use for disadvantaged groups.

As such, a particular focus of transport policy in London has been the promotion of a modal shift toward more sustainable and efficient transport behaviours. In practice, this means increasing the share of journeys using public and active transport – walking and cycling in particular. This is because public transport journeys can be faster, more spatially efficient, allow greater public oversight over transport outcomes, and, through economies of scale and public control, and can allow for both faster rollout of cleaner fuels and cheaper journey costs.

Meanwhile, active transport can promote positive public health and socioeconomic outcomes. Indeed, TfL estimates that if Londoners walked or cycled every possible trip, then around 60 per cent of adults would reach the minimum physical activity level through this alone (TfL 2016a). Public and active transport also complement each other; public transport journeys often involve intermediate stages that can be walked, and TfL has provided travellers with information on walking distances between tube stops (TfL 2017c). Public transport use has helped drive growth in journey stage walking over the last decade (TfL 2016a).

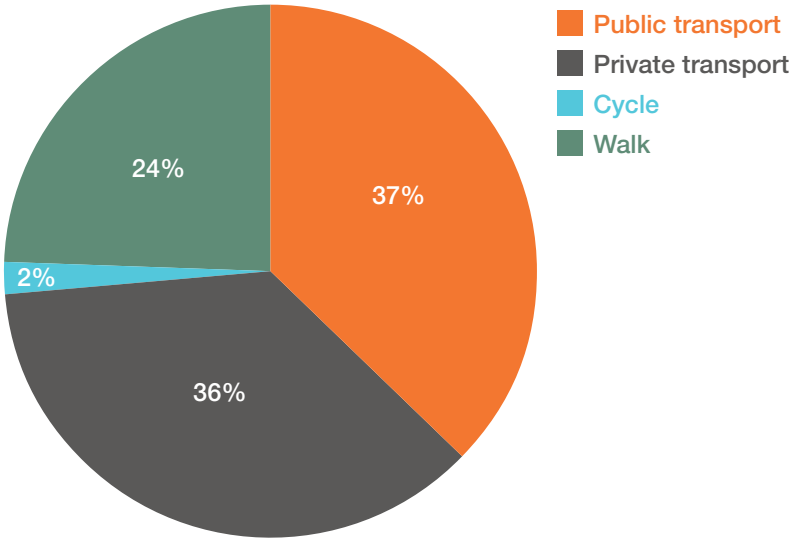
London's transport behaviour is changing

London has experienced an unprecedented modal shift over the last fifteen years (TfL 2016a). Overall, London saw an average of 26.7 million trips per day in 2015, an 18 per cent increase on 2000, and over this time there was a 10.4 per cent net mode shift from private to public and active transport (TfL 2016a). Public and active transport now account for about 64 per cent of all one-way commuter movements in London, as seen in figure 2.2.

FIGURE 2.1

Public and active transport account for nearly two-thirds of trips in London

Trip-based mode shares (%), public and private transport, by main mode



Source: TfL 2016a

While travel behaviour differs across London's geography – with a higher incidence of car use in outer than inner London – the modal shift away from car use is apparent across both areas, with a 5 and 3 per cent fall in the modal share of cars in inner and outer London respectively (TfL 2016a). Overall, 43 per cent of London households have no access to a car, with a quarter more households in outer London owning a car over those in inner London. Urban density and incidence of alternative options are major factors in determining mode share throughout London, with walking and cycling rates in the densest areas of London being double those of the least dense (TfL 2016a).

One of the most remarkable developments has been the growth in cycling, which has increased by 118 per cent across London since 2000, with 193 per cent growth in central London (TfL 2016a). Although the mode share of cycling is still only 2 per cent, TfL anticipates that the full benefits of cycling infrastructure investment are yet to emerge, and that increases in cycling are due to both new and established cyclists making more trips (ibid).

Many factors are driving the modal shift

TfL attributes the overall modal shift to sustained investment in public and active transport, limitations in road network capacity, and wider, structural and behavioural factors (TfL 2016a). Indeed, London's public transport network is one of the most advanced in the world. This is the result of continued investment over the last two decades, which has led to an increase in underground and bus service capacity of 29 and 35 per cent respectively since 2000, and an improvement in reliability of 47 and 46 per cent for underground and bus over the same period (ibid). Improvements in the network have helped London rise above comparable European cities in the mode share going to public

transport, having lagged behind in the 1990s. Satisfaction with the public transport network exceeds an average of 86 per cent across all modes – an increase of around 7 per cent since 2009/10 (ibid).

Furthermore, travel behaviours are being driven by technological developments and demographic change. For example, the frequency of residents foregoing travel has increased by 5 per cent, from 18 to 23 per cent, in the last decade – a trend TfL attributes in part to the increase in informal and remote working opportunities, and the increase in home deliveries enabled by digital technology (TfL 2016a). We turn to the effect of new transport technologies in the next chapter.

Into the future

A combination of policy, improvements to infrastructure and socioeconomic changes have led London to experience an unprecedented modal shift toward more sustainable transport behaviours over the last 15 years. These developments have helped reduce negative transport-related outcomes, with notable examples including the reduction of congestion across central London as a result of the CCZ. However, some of these problems are still set to increase, as in the case of congestion, and are highly entrenched, as with air pollution.

To make matters worse, population growth and demographic change have increased, and will continue to increase, the number of trips and incidence of particular travel behaviours, placing even greater demands on a city with ever-more constrained space (GLA 2014). This could further entrench already severe problems, pushing some toward potentially unmanageable levels. Significant infrastructure investment is needed to combat this, the cost of which the previous mayoral administration estimated at around £200 billion (GLA 2014).

All this comes at a time when TfL is experiencing financial difficulties resulting from the future loss of its general grant from central government, and the new mayor's commitments on fares (LABPC 2016). Therefore, TfL is exploring new approaches to demand management and increased efficiency in the use of new and existing transport system assets and modes. These innovations could either help or hinder the shift towards more sustainable travel behaviours in London. We turn to these issues in the next chapter.

3. EMERGENT TECHNOLOGIES AND CHANGES IN BEHAVIOUR

Developments in digital technology have precipitated an era in which people and resources can be connected without interactions being mediated by third parties. This increase in connectivity has been exploited by entrants into mature markets to successfully challenge incumbent firms (Christensen at al 2015). This 'disruption' may be so profound that the business model of incumbents is almost entirely eroded, as is arguably the case with, for example, Wikipedia and the for-profit encyclopaedia industry.

In transport, these developments have enabled the rise of new models of personal transport services, and accelerated the uptake of existing ones. Digital platforms – be it smartphone apps or websites – facilitate peer-to-peer transactions between those seeking information on or access to transport and the providers of such a service, and are increasingly affecting the pre-digital model of transport access and use in major cities around the world. These services include journey planners, car clubs and on-demand private hire, and, when operating in a network, may enable travellers to move from ownership of vehicles to their use as a service. As such, they are often referred to as 'mobility' solutions or services, emphasising their focus on mobility between destinations through all transport mode systems instead of a choice between competing systems (ACUK 2011).[3]

3.1 THE EFFECTS OF NEW TRANSPORT TECHNOLOGIES IN LONDON

In principle, new mobility services made possible by digital technology could affect:

- the number, efficiency, reliability and affordability of journeys
- the number of vehicles on the road, their occupation levels and fuel mix
- the availability and physical accessibility of different transport modes across time and space in London.

In turn, impacts in these areas will have a net effect on levels of public and active transport use. The results could vary from a net increase, if new services were to act in a complementary way, or a net decrease, if they had the effect of crowding out public and active transport use. Ultimately, these impacts will affect levels of congestion, air pollution and carbon emissions, and help determine socioeconomic and other outcomes in local areas and across the city.

3 In the UK, the term 'mobility' can also refer to policies and support to those with physical disabilities.

In this way, new mobility solutions could help or hinder a shift towards more sustainable forms of travel behaviour. The penetration of these services into existing markets, or the creation of new markets in these services, is at a nascent stage, and so the evidence as to their net effect on key outcomes is limited. Against this backdrop, we now inspect how the major new mobility services in London could affect the move toward more sustainable travelling in theory, and what evidence exists to show this effect in practice.

Journey planning platforms

Journey planning websites and apps allow users to identify the most efficient means to move from one point to another within an urban environment, by providing real-time data and planning functions for public and private transport modes. Efficiency is usually defined in terms of cost and time, though other variables are available, and often journeys are made inter-modally. TfL openly provides data on its services through its own journey planner, or to private app providers through its unified application programming interface (API) (TfL 2017d).

In principle, journey planners could affect the number and efficiency of journeys that users take, as well as the accessibility of different modes. Increasingly, some of these platforms embed the ability to book private transport services, and may even offer financial incentives to use these services (Mills 2017).

On-demand taxi and private hire services

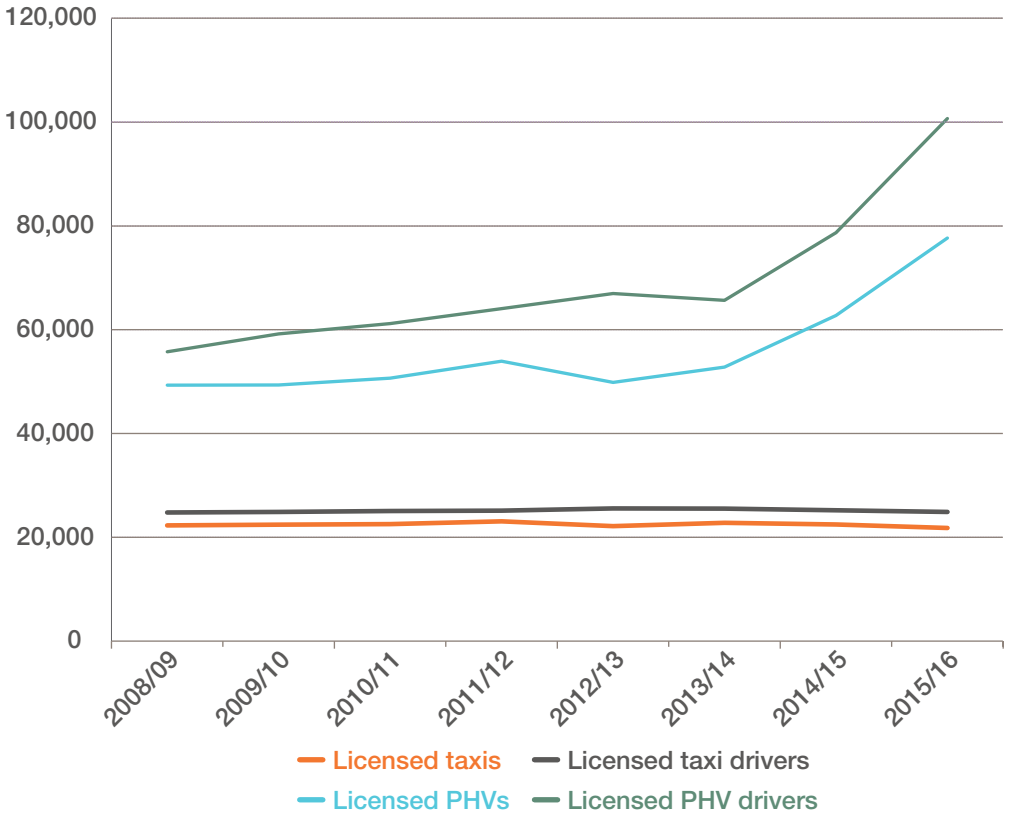
These services facilitate peer-to-peer transactions between passengers and vehicle drivers, lowering transaction costs and increasing the utilisation rate of vehicles. In principle, these services could drive a number of positive transport behaviours; for example, by increasing shared vehicle use and offering a 'first and last mile solution', in which short-hire journeys are used to connect travellers to public transport hubs, particularly in areas of low public transport density (Uber 2017). In doing so, they could complement modal shift efforts, providing an affordable and efficient alternative to unsustainable transport behaviours, helping to lower air pollution and congestion as well as opening up safe and clean transport coverage to areas of low public transport density.

The degree to which these services impact upon these indicators is contentious. Between March 2013 and November 2016, the number of licensed PHVs increased by 70 per cent, from 49,854 to 84,886 (LATC 2017). Over the same period, the number of licensed drivers rose by 72 per cent, from 66,975 to 115,513, while the number of PHV operators fell. The LATC notes that this growth is 'believed to be driven by the exploitation of new technology, which has enabled changes to the way operators and drivers offer services, and the way passengers book journeys'. This suggests that the rise in PHV numbers is increasing congestion in central London during the working day as well as during evening and weekend peaks (LATC 2017). TfL have singled out Uber, one of the largest on-demand hire companies, as having driven the growth in the PHV market, with the launch of its UberX product in July 2013 making it easier, and sometimes cheaper, to find and gain access to a PHV (TfL 2016a). In turn, TfL has concluded that higher induced demand then led more PHV registrations, as illustrated in figure 3.1 below.

FIGURE 3.1

Licensed PHVs, and their drivers, have increased sharply since 2013

Number of licensed London taxis and PHVs, and their drivers, 2008/09–2015/16



Source: TfL (2016a)

Conversely, Uber claims that congestion increases are the result of roadworks and the growth of delivery journeys as online commerce increases (Uber 2017), with an inverse relationship between primary Uber usage times and congestion peak periods as it penetrates previously underserved markets (INRIX 2016). Uber have concluded that 'licensed PHVs are not a long-term driver of increased congestion', and that they actually have a role in reducing congestion (Uber 2017). According to Uber, its uberPOOL service, which shares PHV hire between users, has made over 2 million trips in London since December 2015, and saved 1.3 million miles driven, 98,000 litres of petrol and 231 metric tonnes of CO_2 (ibid).

Car clubs

'Car clubs' allow rental of shared vehicles on a pay-per-use basis.[4] Two main car club models exist in London: round-trip, where vehicles are picked up from and returned to the same on-street or off-street bay; and flexible, where vehicles are located on-street, in undesignated bays, or off-street, and do not have to be returned to the same pick up location. In offering flexible and short-term loans, car clubs build

4 'Car clubs' are referred to as 'car sharing' outside of the UK; within the UK, 'car sharing' can be used to refer to the sharing of journeys in a private car, or 'ridesharing'.

on and complement the incumbent vehicle rental service model. Car clubs – hereafter referring to both round-trip and flexible models – have existed in London for around a decade, and their services are now predominantly accessed through websites and smartphone apps, providing real-time information and booking services.

Car clubs could offer an alternative to private vehicle ownership, reducing or negating the high costs of ownership for vehicle users, and increasing vehicle utilisation rates, leading to a net reduction in the number of vehicles on roads. In conjunction with these effects, car clubs could improve access to public transport networks, leading to an overall net increase in public and active transport. Recent innovation within the sector has exploited digital technology to influence user behaviours, including adaptive demand pricing.

The evidence for these effects is growing and is apparent in other cities (Martin and Shaheen 2016, Team Red 2014). In London each year, Carplus, a car club accreditation body and shared transport NGO, conducts a survey of London's car club market and its customers (SDG 2017). In 2016/17, car club membership in London was around 193,500 – behind other cities, such as Milan (ONSM 2016). According to the survey, both flexible and round-trip car clubs are having a tangible impact on transport behaviour.

- **Lower car ownership**: 19 per cent of new flexible and 24 per cent of round-trip members sold or disposed of a car and there were a total of about 31,000 vehicles sold or disposed of as a result of car club membership across both models.
- **Lower car and higher sustainable transport use:** members reduced car use, with an average reduction in miles driven of 239 and 570 per year for flexible and round-trip respectively, and used more public and active transport than non-members.
- **More efficient use:** car use was more space efficient, with average occupancy of about 2.2 (flexible) and 2.6 (round-trip) people per car across users, compared to 1.6 people per private car (TfL 2015d). The average booking for round-trip car clubs was for 26 per cent of the day, and so car clubs are likely to have considerably higher utilisation rates than private cars, which are estimated to be used less than 5 per cent of the time. Vehicles were often used for journeys that would have been unsuitable for other modes.
- **Cleaner vehicles:** 80 per cent of car club vehicles are in the lowest three emission bands, and the average car club car emits 29 per cent less CO_2 than the average private car. The proportion of diesel cars in car club fleets fell from 47 per cent in 2014/15 to 5 per cent in 2016/17. By the end of 2017, it is anticipated that all of the diesel vehicles in the car club fleet will have been replaced. Car club members have high levels of interest in using electric vehicles (EVs).

In accordance with the positive evidence on the effect of car clubs, the London Car Club Coalition was founded in 2014, and is comprised of car club operators, vehicle rental groups and key governance stakeholders, including the Greater London Authority (GLA), TfL and London councils (CCC 2015). The Coalition subsequently produced a car club strategy with an explicit aim to grow the car club sector to 1 million users by 2025,

estimating that such growth could reduce traffic by up to 2.1 per cent, CO_2 emissions by up to 1.4 per cent, and NO_x and PM10 emissions by a central estimate of 0.5 and 0.2 per cent respectively (CCC 2015).

Other shared transport options

London is home to a number of **bike hire** and sharing schemes. Since it was introduced in 2010, TfL cycle hire, the largest scheme, has been extended further across London, and the service has been opened up to casual members. In 2015/16 there were 9.9 million hires; a 2 per cent fall on the previous year, likely as a result of high levels of road network construction activity, but with use now growing again (TfL 2016a). Satisfaction with the scheme is high and, according to a recent survey of users, 46 per cent started cycling as a result of the scheme (Bikeplus 2017). Like the TfL scheme, other bike hire and share services can be found at key transport interchanges and are making use of smartphone technology for planning and payment. There is some evidence to suggest that these schemes lead people to use more public transport (ibid).

There are also a number of **ridesharing and peer-to-peer rental** schemes in London, offering the ability to share rides, or the on-demand rental of privately owned vehicles.[5] In both cases, vehicle utilisation rates could be increased as otherwise unused vehicles are used to make journeys or journeys have higher occupation rates. In turn, this could lead to a net reduction in vehicles on the road, alongside reduced dependency on ownership and the financial costs it entails, with ridesharing able to save individuals an estimated £1,000 per year on transport costs (Carplus 2014). Though growing in size, the markets for ridesharing and peer-to-peer rental are still relatively small compared to other mobility services.

Furthermore, there are other **emerging models of shared transport** which operate elsewhere but are yet to penetrate deeply into London mobility markets. These include:

- **point-to-point car clubs**, in which a vehicle hire starts at one designated bay and ends with the parking of the vehicle into another, though necessarily the same, designated bay
- **demand-responsive taxi services**, in which an app can be used to hail a shared vehicle and the passenger is picked up from a location agreed through the platform (examples of these services are in operation outside of London)
- **social enterprise ownership models**, such as community interest companies and co-operatives, that reinvest the profits from their mobility services back into operations that have an explicit social and environmental focus
- **peer-to-peer rental with telematics technology** that overcomes the technological limitations of existing peer-to-peer rental by equipping vehicles with a black box monitoring device that allows for ease of access and monitoring

5 Here, ridesharing refers to the sharing of journeys by individuals in a private car, which is also referred to as car-pooling, car sharing, or 2+ car sharing in the UK context. Peer-to-peer car rental is used to refer to the on-demand rental of privately owned vehicles.

- **fractional ownership** of vehicles, whereby a number of people own a share in the use of a vehicle, in much the same way as shared ownership works through a property timeshare
- **aggregation of mobility services** onto single platforms.

As with the more established services listed above, emergent services could be integrated into London's transport system to complement efforts to drive more sustainable travel behaviours, with, for example, social enterprise models unlocking shared transport options for low-density, low-income areas, and demand-responsive taxis offering a 'first and last mile' solution to enhance existing modes.

3.2 A FORK IN THE ROAD

While the effects of some new mobility services are becoming increasingly clear, others are not. Indeed, as with any transport system, the effect of these services in isolation is likely to differ from the aggregate effect of their operation within a network of new and existing transport options. We can categorise these network effects into those enabling positive or negative progress on air pollution, congestion and other outcomes.

Positive network effects

In principle, new mobility services could, as a network, act to complement existing efforts to achieve more sustainable transport and travelling behaviours. Together, the availability of an array of new shared vehicle services, public and active transport, and journey planner platforms that allow ease of interaction with this system, could provide a seamless and integrated mobility environment throughout London. This ambition relies on the supply of services and infrastructures in an urban environment that allow for integration between transport modes, giving users the ability to move smoothly around a city, and to make a change from personally owned modes of transportation towards transport solutions that are consumed as a service.

For example, a ubiquitous car club market, exploiting the network benefits of different models, could offer access to vehicles for essential travel and in parts of London with low public transport at a lower price and with higher penetration of ultra-low emission vehicles. This would present an alternative to private vehicle ownership and increase public and active transport use throughout the city as people seek alternatives means of travel. On-demand private hire and car-pooling could then further increase vehicle utilisation rates, leading to a net fall in vehicles and journeys travelled, and complement public and active transport by offering 'first and last mile' services, which could improve access and affordability to mobility for disadvantaged routes.

The integration of these services through journey planners and the analysis and modelling of their associated data offers unprecedented scope to optimise transport services across London. It may be, for example, that the optimal mode for an evening commute in a part of outer London is the bus, while late at night it is a shared hire service.

These positive network effects are directly analogous to those already apparent from the use of integrated ticketing through the Oyster system, and the availability of high quality public transport alongside active transport services and infrastructure. New mobility services could further strengthen these effects. A recent study in Lisbon by the International Transport Forum (ITF) modelled the impact of replacing all car and bus trips with shared vehicle trips, including shared taxis, 'taxibuses' and public transport, providing a seamless mobility system in which private ownership was no longer necessary (ITF 2016). The study found that this system required 3 per cent of the cars to make the same trips in 24 hours because of higher utilisation and occupancy rates. There was a resulting 34 per cent fall in CO_2 emissions, and reductions in air pollution, with higher utilisation also leading to faster turnover of vehicles, and thus more rapid clean technology penetration. Congestion dropped to negligible levels, enabling higher and more equitable access to healthcare, jobs and education. Finally, smaller vehicle fleets meant that the parking requirement fell by 95 per cent, providing enormous opportunities for spatial renewal to increase liveability, including public parks, broader pavements, and more and safer cycle lanes.

In this scenario, new mobility services acted as a complement to existing measures to reduce negative outcomes in the city. These virtuous network effects rest on a foundation of high quality and accessible public and active transport options, and are enabled by key new mobility pillars, such as car clubs, which, crucially, allow for car use without ownership. As the study shows, the potential positive benefits of effectively incorporating these services into transport networks are profound, and highly achievable with current levels of technology.

In the future, the role of journey planners as the gateway to this network may change to become a provider of 'mobility packages'. These packages could be formed by bundles of mobility services customisable to consumer needs and tastes and at an aggregate price lower than the sum price of individual journeys, in much the same way as offered by travel cards, or by mobile phone service providers (Kamargianni et al 2015). Further into the future, the advent of autonomous vehicles is likely to further disrupt transport markets, potentially providing increased accessibility, efficiency and penetration of clean vehicles. Ultimately, the network efficiency of London's transport system is maximised when travel is minimised, and with it, when the costs associated with transport use and infrastructure, including the opportunity cost of freeing up space and changing lifestyles, are reduced.

Negative network effects

These network effects could also be negative, undermining efforts to realise more sustainable travelling behaviours by, for example, cannibalising public and active transport as travellers increasingly opt for low-cost on-demand private hire. In this world, the optimisation of vehicle hires and on-demand taxi options provide cheap alternatives to almost all other travel modes. Deals could be made with journey planner platforms to incentivise the use of private mobility services, which could create a shadow private transport network, with large-scale data collection increasing the power of incumbent firms over public operators and decision-makers.

The advent of a mobility package market could accelerate this trend, with 'premium' packages providing users with the ability to avoid the pitfalls of 'budget' packages, including, for example, the requirement to pass through sponsored locations during journeys, such as shops, and other mobility limitations. Accessibility to key opportunities could be eroded, and already large socioeconomic inequalities further opened up, while the consolidation of operators would allow for bargaining power over governing institutions that would erode air pollution and congestion charging, leading to impaired outcomes in these areas. After a while, congestion could reach levels so high that mobility markets are no longer able to operate effectively, and the liveability of the city is severely affected. The advent of autonomous vehicles could further entrench and accelerate these negative outcomes.

Towards positive network effects

These are both illustrative futures, but ones rooted in the premise that the boundaries between public and private transport are already blurring as a result of disruption to transport markets. This has changed mobility behaviours and led to a shift, albeit small, in the balance of power in London's transport system. The nature of these changes, and the fears over their net effect, should serve to educate hypotheses on what could happen if regulators are not prepared for future disruption, which could include mobility packages and autonomous vehicles.

London is also a hotbed for digital and transport innovation and could gain from continuing to nurture this role. However, while new services have grown in London, others have withdrawn from the capital entirely (BBC 2014). The attractiveness of London for mobility innovators impacts its ability to develop and gain from new services and technologies that could otherwise improve the liveability of the city. Furthermore, London's attitude to new mobility markets also impacts its comparative advantage in these markets. Together, the liveability and economic potential of the city will affect how it competes against other major cities as the UK negotiates its position in the world after leaving the European Union.

The ITF has concluded that 'shared mobility benefits depend on creating the right market conditions and operational frameworks' (ITF 2016). As with the regulation of all technological change, decisions that are made now – and the vision that underpins them – will determine how these technologies affect the environment, society and economy of the city. We now turn to this vision and its framework.

4.
POLICY RESPONSES

In *A City for all Londoners*, the mayor sets out his administration's ambitions for London (GLA 2016a). Sitting within this wider vision, those ambitions pertaining to transport will be articulated in the forthcoming *Mayor's Transport Strategy* (MTS); a statutory document which, along with the *London Plan* and *Economic Development Strategy*, will form the strategic policy framework for the economic and social development of London (GLA 2010b). The MTS may focus on a number of key areas, including the following.

- Sustaining the modal shift to more sustainable forms of transport behaviour through increasing public transport capacity.
- Improving the efficiency of road use as traffic volumes increase and road space reduces, linking these developments with the modal shift to decrease congestion.
- Pursuing high-density, mixed-use development with high public and active transport connectivity as the preferred model for the future, as transport can play a key role in increasing the supply of housing.
- Growing markets for cycling and other active transport, while ensuring safety and the efficient development of key infrastructure.
- The innovative approaches that are required to tackle London's entrenched road transport problem (TfL 2016a).

It is our view that all these areas must remain the primary focus of transport policy in London, and that these policies must continue to realise a shift towards more sustainable transport behaviours through the increased provision of public and active transport. To achieve this, transport policy must adequately respond to the arrival of new technologies, to ensure that they play a positive role within a transport system seeking to become more efficient, cleaner and more equitable.

4.1 A VISION FOR NEW MOBILITY SERVICES IN LONDON

As the previous chapter showed, new mobility services have arrived and are increasingly disrupting behaviours and affecting policy efforts to impact key transport-related outcomes in London. It is likely that this disruption will continue and, if the experience of other sectors affected by digital technology is anything to go by, this disruption will accelerate, with potential new developments including a greater role of journey planner platforms and the advent of autonomous vehicles. These developments will require a response from the mayor and TfL.

The window of opportunity for action is closing

As with most areas of public policy, such responses usually lag behind changes. Indeed, the very nature of rapid technological change means that formulating a public policy response in advance is very difficult. However,

recent developments, especially the growth in PHVs, offer advance warning of further disruption and serve as a cautionary tale for when policymaking is unprepared for responding to the rapid change brought about by digital technology. It is our conclusion that a future of negative network effects is made more likely if an adequate response is not forthcoming from London's government, echoing the conclusion of the ITF that 'public authorities must guide the deployment of shared mobility systems and anticipate their impacts', and that 'well-informed and sometimes bold public policies will be necessary to guide the process of change' brought about by new mobility technologies (ITF 2016).

Indeed, the scale and pace of change ushered in by digital technology in transport is such that London's ability to control its own transport future could be increasingly eroded by new services that offer ease-of-use without necessarily respecting key public policy objectives. These services could be provided by large digital market incumbents well-endowed with lobbying power, market influence, and data-collecting capabilities. Furthermore, these firms are beholden to different incentives than TfL, and are not experienced in administrating transport systems. As such, there is a limited window of opportunity for action, and decisions that are made now will create a path dependency through which future policy possibilities are determined.

This means that the decisions made by the mayor and TfL in this term are crucial to London's future, as well as its present. It is our view that the risks associated with inaction are intolerably high, and that the mayor should act in this mayoral term.

Ensuring the positive impact of new mobility services

In responding to existing disruption and planning for future developments, the mayor and TfL should draw on an understanding of the potential of positive as well as negative network effects arising from new mobility services. As the last chapter showed, there could be a great opportunity to exploit the positive potential of these services to complement transport objectives. Indeed, it can be argued that these technologies offer unprecedented opportunities to realise such outcomes; opportunities that were unimaginable even five years ago, and that are unavailable to large infrastructure projects. This potential has already been recognised by mayoral administrations, as evidenced by the creation of the London Car Club Coalition, and the recent call for a national scrappage fund that provides 'mobility credit' to low-income households (TfL 2017e). We think that the next step to ensure that new mobility services complement existing transport policy is to define an overall vision of how these services fit into London's transport system and policy programme, and to provide the framework through which London can get the most out of these developments.

Therefore, we recommend that the **mayor of London incorporates a vision and framework for new transport technologies into the MTS, in which shared transport and digital technology realise their potential to drive positive transport outcomes**. This vision should include all new modes and services, and detail how they can interact with London's transport network to deliver positive network effects. It should also provide the market framework and regulatory focus through

which this vision could be realised and made robust as disruption continues. We recommend that this framework should include the following items.

1. An **urgent audit of technological developments** to gain a better understanding of the size of new mobility markets and their potential and future effects upon key transport-related outcomes, along with continuing evaluation through a monitoring framework. This audit should be performed quickly to minimise investor uncertainty and the risk of innovative mobility firms leaving the London market, as well as to minimise negative networks effects now and into the future. These developments should include the effect of digital technology on the commercial sector, such as the rise of home deliveries and the impact this is having on congestion.
2. The definition of a **set of overall positive outcomes for London's transport network, and how each new service and mode can contribute in a network** to support the uptake of more sustainable travel behaviours and the continued modal shift, including key metrics to be used to define and measure these outcomes. In particular, this should include a clear vision and framework for how new and emergent technologies can complement existing services, such as the contribution of short journey hire in delivering 'first and last mile' solutions. It should be clear how new developments interact with incumbent services, including the existing rental, taxi and PHV trades; cover London's diverse and inconsistent transport geography; and include all demographics and communities and their unique requirements.
3. An understanding of how existing **policies interact with new mobility technologies**, including the planned ULEZ.
4. The **rapid development of an explicit market framework for new mobility markets**, including in existing markets, such as journey planners, on-demand private hire services and car clubs, and potential future markets, such as mobility packages and autonomous vehicles.[6] This framework would set the conditions by which providers operate, and how this interacts with the existing taxi, PHV and rental frameworks, and should be developed in collaboration with operators of new mobility services. Furthermore, the framework should specify how the contribution of existing and emergent modes differs across London's geography.
5. It should be clear **how this framework will be administered by London's public institutions** in a way that caters to their diverse objectives and incentives, particularly in the case of London's boroughs. These measures could include an extension of TfL's transport innovation capabilities and those forums that facilitate innovation discussions between key stakeholders.
6. The provision of **guidelines for London's boroughs** on how to best gain from new mobility technologies and how to develop them within boroughs.

6 While having reviewed some of the literature on the disruptive potential of autonomous vehicles, they are beyond the scope of this report. However, the report's central recommendation – of developing a vision for the role of new services and technologies in London's transport mix and providing a framework to achieve this vision – is made all the more important by the potentially highly disruptive impact of autonomous vehicles.

7. The provision of **guidelines for private operators** on the new market framework and on how to work with the GLA, TfL and boroughs in developing and implementing services that cater for specific needs.
8. The inclusion of measures to **help households and businesses understand this vision** and how it can benefit them and the city.
9. An understanding of how new mobility solutions could increase spatial efficiency in London, offering alternatives to car-centric development, and how this potential will be addressed through **consistency with the London Plan**.

We expect that this vision and its enabling framework will have to address potential conflicts between ensuring innovation – through allowing competition between a plurality of operators – and maximising the network benefits of operating an overall transport system in London. Achieving an effective balance will be no mean feat, and the mayor should seek a middle way between the failures of the franchising model seen in the UK's mainline railway system, and the increased capture of public transit administration by multinational technology firms seen in America (Harris 2016).

4.2 DELIVERING THE VISION

A previous, analogous vision to that advocated above is the introduction of the Oyster payment system in London. The Oyster system provides ease of payment and navigation through supported modes for the user, and realises the potential of new technologies while providing increased efficiency and a strong business case. It is our view that a similar ethos should drive London's reaction to new mobility services and, as in the case of the Oyster system, this requires attention to key policy areas.

As such, we now turn to TfL's role, particularly with regards to data, the development of the car club market, and that of the EV charging network.

The role of TfL

In discussing the market conditions and operational frameworks for successful utilisation of new mobility services, the ITF suggests charging a 'single entity with matching demand and supply' across shared transport options, though also cautions that 'authorities must carefully reflect on its statute and the supervision of its performance in order to protect consumers from market power abuse and to ensure efficient outcomes' (ITF 2016). In London, the mayor and TfL possess the means by which to protect against abuse of market power, and to ensure efficient outcomes. These means should now be extended to new mobility markets, in order to decrease the potential for market capture and inefficiency. Primarily, these markets operate through digital platforms, and so incumbent firms collect enormous amounts of data on travel behaviours. These data are foundational to these firms' business models, but could also be used to increasingly monopolise on certain services.

Therefore, we recommend that **TfL becomes the central intermediary for mobility data in London**, acting as a neutral, third-party platform through which data is collated, and equal access by all mobility

operators is guaranteed. This would allow companies to share and exploit data within a competitive environment, minimising the chance of monopolisation of service provision through the development of large stores of proprietary data. TfL could also explore the provision of setting up a single sign-on for service payment, offering the means by which consumers can pay for services easily and securely while allowing providers to differentiate their offering through platforms, for example. As the public body responsible for London's transport system in London, it is our view that TfL are best placed to act as this intermediary.

Though these steps would require negotiations between individual mobility firms, it is our view that the potential costs of inaction could be greater than those required to establish such a system. Therefore, it is imperative that TfL acts this mayoral term. The potential for increasingly monopolistic behaviour from large firms is high, while smaller firms are already struggling; and these troubles could be amplified without measures to ensure competition. Furthermore, open access to mobility data could drive more competition and innovation in these markets, and, by acting as an intermediary, TfL would be able to ensure standards of data safety and security and insist that firms operate within the market framework set by the mayor's transport vision. This framework should be developed in tandem with TfL's role as a data intermediary and provide payment consistency, with an understanding that these structures could offer a powerful means through which to drive positive public policy outcomes.

Finally, these issues affect cities throughout the UK, and so the mayor and TfL should continue to work with central government to develop standards for data systems, and begin the process of extending regulatory responses to new mobility services across the country.

Mobility as a service platforms

For those with access to smartphones, journey planner apps are increasingly becoming the chief means by which travellers interact with transport options in London. The functionality of these platforms is increasingly expanding to include mobility packages that offer prices for multi-legged and multi-modal journeys, which cost less than the per-unit price and can form part of monthly packages: so-called 'mobility as a service' (MaaS) platforms (Kamargianni et al 2015).[7] This is not a new idea in London; TfL already offer travel cards under agreement with rail operating companies. However, the central innovation of these platforms is to provide ease-of-access to all transport options, and their appeal to on-demand, service-orientated consumers.

These innovations led the University College London Energy Institute to investigate the feasibility of a MaaS platform in London and, accordingly, advocate its development (Kamargianni et al 2015). They suggested that TfL is best placed to implement such as system. This is a vision of transport in London in which TfL acts as an explicit integrator of mobility services. Whether or not TfL were to take on such as role, the potential emergence of market in mobility packages is an important and potentially highly disruptive development. As such, we recommend

7 See, for example, the planned 'Whim' service in the West Midlands. http://whimapp.com/uk/

that **TfL should assess the potential for a MaaS platform market in London** and develop recommendations for policy responses, including a market framework and the feasibility of a TfL MaaS platform, for scrutiny by the mayor, London Assembly, London boroughs, and private operators. Without understanding a potential MaaS market, and acting accordingly, London's transport system could increasingly be at risk from the power and influence of large private firms, potentially limiting the benefit that MaaS platforms could deliver to London. Furthermore, a publicly or community owned MaaS platform could generate revenues to be reinvested into driving positive outcomes in London.

Road charging

Broadly, many transport-related problems above result from movement behaviours not reflecting their true costs – whether that be economic or otherwise. Externalities resulting from London's transport system are not adequately internalised by individuals and businesses when they make decisions on how to move throughout the city. These costs not only arise from air pollution, congestion, carbon emissions and other public health problems, but from the inefficient use of assets, such as parking space. The introduction of the CCZ and the planned ULEZ are examples of road pricing schemes that seek to further price negative externalities. The enforcement, integration and expansion of these schemes is made further possible by digital technology, which could allow for cheaper alternatives to existing systems, such as the network of automatic number plate recognition cameras used in the CCZ. However, as TfL have noted: 'the impacts of usage-based charging are largely untested, the technology requirements are complex and there are significant potential social and economic impacts which would need to be better understood' (TfL 2017b). Given this, we recommend that **the mayor should mandate TfL to investigate the potential for a smart charging system and an integrated road pricing scheme in London**, taking advantage of digital technology, and with the objective of implementing both after 2025. This investigation should form part of the development of the vision and framework for mobility services in London set out above and include in its scope all transport externalities, including parking. A dynamic road pricing scheme in London could create a large revenue stream for TfL, as well as effecting more sustainable transport behaviours.

Car clubs

Cars will continue to play a role in London's transport mix – albeit an increasingly diminished one, particularly within central London. Car clubs provide facilities that enable a higher incidence of shared use across the car fleet and, are therefore of foundational importance in delivering a transport network in which a modal shift becomes a possibility for a greater number of groups throughout London. Furthermore, car clubs provide a facility through which rapid changes to the fuel mix of vehicle fleets can be more easily achieved, supporting the objectives of policies such the ULEZ.

There is significant potential for the growth of car club markets across London, as well as into areas in which there is low public transport coverage and a high incidence of car ownership (CCC 2015). Assessing

the barriers to this growth, the London Car Club Coalition (LCCC) identified three main challenge areas: policy and governance, including the decentralised nature of parking and street governance in London; delivery insufficiencies, such as the limitations of the EV charging network; and awareness and visibility issues, including a lack of understanding within the general population.

It is our conclusion that while steps have been taken to engage with the concept of on-demand car hire by successive administrations, the mayor should provide an explicit vision of how the car club sector and each of its models could complement his transport objectives and, in doing so, how the barriers to uptake given by the LCCC can be lowered. Therefore, we recommend that **car clubs should be a key part of the mayor's vision for London's transport system**, and that the MTS should include measures for how car clubs can help achieve key transport objectives. This vision should set the principles for operation and of market growth, with an understanding of the appropriate spatial development of services and the role of each model in providing essential travel. The vision for car clubs should be part of the wider framework set out in the MTS on new mobility technologies, and include all models currently provided by operators. It should also include the LCCC goal to achieve 1 million car club users by 2025 (CCC 2015), and ensure innovative solutions are used to contribute toward positive outcomes, including, for example, the integration of one-way models with public and active transport and dynamic pricing functions.

Foremost among the barriers to this growth is the lack of an overall body for parking and street management policy in London. In the case of parking, responsibility is shared across TfL, the boroughs and the City of London and, when considering off-street parking, public and private landowners (CCC 2015d). As a result, car club operators must navigate through the diverse policy approaches of boroughs, many of which have to manage often competing incentives for parking, including revenue, the views of residents and access requirements. Furthermore, boroughs are experiencing resource constraints as a result of central government budget reductions, and so sometimes find it difficult to prioritise or accommodate car club development. Overall, car club operators often find it hard to convey the potential benefits of the sector to boroughs, who are in need of guidance and support.

Therefore, we recommend that **TfL and boroughs work with operators to develop borough-by-borough agreements to enable car club development**. These agreements should explicitly recognise the benefits and scale of impacts that the variety of car club models could contribute to a borough, as part of the mayor's vision for the integration of new mobility services into London's transport network. The agreements would also provide car club operators with investor certainty, with clear guidance for the boroughs on how to enable the positive development of the sector in their area. This would be structured around three components: policy outcomes and priorities, the use of highway space, and use by borough staff. In particular, guidance should be provided on how to repurpose bays and upgrade signage across boroughs.

This support should draw upon the expertise of London Car Club Coalition, which already convenes key public and private stakeholders, and acts as an honest broker. Furthermore, this guidance should co-ordinate with the large traditional car rental market in London, with the understanding that car clubs, as an extension of the car rental model, ensure Londoners have a full suite of options available through which a modal shift can be realised.

The EV charging network

Strategies for the development and uptake of low emission vehicles and technologies in London include the continued spread of the EV charging infrastructure. There are now over 1,300 charging points across London – though this is considerably lower than the 25,000 the last mayor sought to install by 2015 (LAEC 2014), and concerns have been raised as to the reliability and functionality of charging points (Sharman 2015). Furthermore, the proposed ULEZ, in increasing the cost of driving certain vehicles in the capital, will need to be complemented by a larger EV charging network with high levels of functionality and ease-of-use. Accordingly, the current administration has said it will improve the EV charging infrastructure, including the development of a rapid charging network with dedicated sites for taxis (GLA 2016b).

However, it is our view that the scale of modal shift away from polluting vehicles requires a more rapid rollout of EV charging infrastructure, and the guarantee of certain standards across it. We recommend that **the mayor introduce a new market framework for EV charging networks in London, including regulation to ensure their proper functionality, ubiquity, interoperability and fair access for mobility operators and users**. This framework should enable the rapid expansion of charging infrastructure, particularly in catering for the low emission requirements placed on taxis and PHVs. These efforts will need the input of a number of key stakeholders, including district network operators, charging point providers, mobility operators and vehicle manufacturers, who are well positioned to take a market proposition to the mayor.

Furthermore, the framework should include provision for public sector entry into the market, with the potential for private sector seed funding being provided through a levy on use, offering up a future income stream against which TfL can borrow to invest in charging point expansion. However, it is our view that it is not the primary responsibility of the public sector to own and maintain this network, and that the private sector, as a principle beneficiary of such a network, must take a leading role. This framework should sit within that for the integration of new mobility services into London's transport network and, the mayor should explore models of regulation so that positive outcomes are maximised.

Finally, as with any market in hard infrastructure, this framework should be adaptable to technological change, appreciating, for example, the potential of hydrogen vehicles and the attendant requirements for filling stations.

The future of the digital economy

The focus of this report has been the impact of digital technology on transport in London. The nature and speed of digital disruption in transport means that, no matter its direction, the mayor's response to these developments is likely to have a profound effect on how

Londoners move around the city. Furthermore, by the merit of London's world-leading role in transport policy and provision, the mayor's actions could also influence the approach taken by the rest of the UK and the world in responding to the impacts of digital technology on transport. As in London, these will necessarily broach a wider set of issues typical of recent digital disruption beyond the scope of this report, including: labour rights, safety, tax practice, displacement of business models and working practices, data, privacy, and the economic and political power of incumbent firms.

In developing a response to digital disruption of a key policy area within an urban environment, the mayor's approach to new mobility developments will shape the principles through which the state seeks to affect the development of the digital revolution and its effect upon societies and economies. As we have seen with transport, this revolution has enormous potential to help or hinder progress towards realising a more equitable, efficient and cleaner world. With the power of digital firms growing, it is imperative that governments of all levels engage with the effects of digital technology across all policy areas.

No natural law dictates what form future digital disruption should take. We join others in recommending that the **mayor of London appoints a chief digital officer for London**, whose remit would include the development and co-ordination of efforts to understand and anticipate the potential of digital technology, and ensure the timely and effective response of London government (CL and LF 2016).

5. CONCLUSION

> *'The industrial revolution followed… upon a revolution in scientific method. But it is taking the revolution many centuries to produce a new mind.'*
> John Dewey, *Democracy and Education* (1916)

Negative transport-related outcomes have always existed in London. The city's current problems are directly analogous to the experience of past generations who navigated the toxic smoke of its multiple railways, the disorganisation of a Thames cluttered by boats, and the exclusionary cost of safe and speedy travel (Lawrence at al 2015).These generations also dealt with disruptions to transport from new technological developments. Foremost among them were the watermen who ferried people and products across the Thames and were faced with the constant threat of obsolescence at the hands of emergent technologies – from the bridge to the carriage (Ewens 2003). Over time, the watermen lost out to the convenience and lobbying power of new technologies, such as the hackney carriage, or adopted them, in the case of commuter and pleasure cruises today. Indeed, it was the aggregate adoption of these new technologies and their entrenchment into London's transport mix that defined the latest iteration of negative outcomes caused by transport – the most recent being the diesel engine and its large contribution to dangerous, illegal levels of air pollution.

TfL and successive mayoral administrations have created a system that has moved London far from the chaos of the Victorian era, securing the capital's status as an attractive global city. However, air pollution, congestion, and the opportunity costs imposed by London's transport infrastructure are set to increase or remain entrenched. Change is occurring, but not fast enough.

The advent of changes to London's transport mix and its commuter travel behaviours resulting from digital technology offer an unprecedented chance to combat these problems. As this report has explored, the potential positive benefits of effectively incorporating new mobility services into transport networks are profound, and eminently achievable with current levels of technology. Positive impacts are already apparent, with car clubs, for example, already unlocking positive travelling behaviours.

Having always been a world leader in transport innovation, London now finds itself at a crossroads. The city will continue to lead if it boldly embraces new mobility developments; realising their extraordinary potential to improve the city and the lives of those who live in it. A window of opportunity currently exists in which action can be taken by London's government to realise these ends, but the pace and scale of change puts a time limit on this opportunity. The mayor should act in this term, beyond

which this window may close. He should incorporate into his transport strategy a vision for how these new services and technologies successfully fit into London's transport system, and institute a public policy and market framework through which this vision can be achieved. In doing so, he will be offered the opportunity to shape the role of the state in realising the potential of the digital revolution.

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