MaaSLab

UCL ENERGY INSTITUTE

Transport for London

Londoners' attitudes towards car-ownership and Mobility-as-a-Service: Impact assessment and opportunities that lie ahead

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Executive Summary

The report "Londoners' attitudes towards car-ownership and Mobility as a Service: Impact assessment and opportunities that lie ahead" provides insights about Londoners' attitudes towards car-ownership, shared mobility services and Mobility as a Service (MaaS) as well as an impact assessment about a potential introduction of MaaS in the city. The report has been prepared for Transport for London (TfL) by MaaSLab at UCL Energy Institute, University College London (UCL).

Mobility in London and Challenges

London has changed substantially over the past two decades, both in terms of transport activity and in terms of economic and social characteristics. The period from 2000 onward saw significant improvements in public transport modes' capacity, quality, coverage and ticketing integration, and the congestion charge zone was introduced. New mobility services, such as vehicle sharing and ridehailing schemes have also been initiated offering convenient alternatives to private car usage.

At the same time, TfL freely released its key data allowing for hundreds of new products and services to be developed that respond to Londoners' growing demand to access information about transport services via their smartphones. The effect of such efforts has been successfully reflected in a habitual change over the past decade, leading to an increasing number of Londoners willing to take up alternative transport services rather than sticking to their own cars.

However, London's traffic congestion is getting worse and the same is happening with air quality. Improvements in vehicle technology alone cannot solve the problem. More vehicles need to be taken out of the network if London wants to be a liveable city. London could lead a revolution in car use and car ownership over the next decade, by separating the two. Meanwhile, the public and private mobility services that operate in silo should be integrated to offer convenient alternatives to private car usage. New mobility concepts, such as Mobility as a Service, that are built on transport system integration, Internet of Things and sharing economy principles could contribute towards this vision.

The Mobility as a Service Concept

The MaaS model covers several concepts that have been extensively discussed in the transportation sector during the last decades. These are the integration, interconnectivity and optimization of the transport services, smart and seamless mobility, and sustainability. The model also includes concepts that have recently emerged via the Internet of Things and the sharing economy, such as the term "as a service" and personalisation. MaaS envisages enabling a co-operative and interconnected single transport market and providing users with hassle free mobility. Via MaaS, travellers can purchase mobility services that are provided by the same or different mobility operators by using just one platform and a single payment. MaaS users could cover the travel needs not only in their home-city, but anywhere around the world where MaaS schemes are available.

Objectives and Survey Design

Although there are a lot of on-going discussions about MaaS, so far there is no quantified evidence about Londoners' preferences for sharing mobility and MaaS products, and the impact MaaS could have on mode choice behaviour and modal shift. Against this background the objectives of this report are to provide to the transport authority of the city insights about:

- citizens' attitudes towards owning and using a car in London;
- citizens' willingness to shift from vehicle ownership to vehicle usership;
- Londoners' attitudes towards MaaS and their preferences for MaaS products;
- potential modal shifts in the MaaS era and the opportunities that could arise for the public transport system of the city; and

- the impact MaaS could have on the society, economy, environment and air-quality of London.

The data used for the analysis in this report was collected during the London Mobility Survey (LMS), a survey designed by the MaaSLab. LMS incorporates several parts of the London Travel Demand Survey, and has also been enhanced with additional detailed questions about usage of new mobility services (i.e. car clubs, ridehailing etc.), costs of car-ownership, 7-day smartphone-based tracking and stated preference experiments about MaaS.

Attitudes towards owning and using a car in London

According those survey respondents who own cars, owning and driving a car in Greater London does not necessarily make their life easier or more convenient. Many of them stated exactly the opposite as owing and using a car comes with a number of pain points that cost money and time.

- The average cost of the first vehicle ownership has been estimated to £233.5 per month (excluding maintenance and MOT costs) and 34% of car-owning participants stated that owning a car is a big expenditure for their household.
- The majority of car-owning participants claimed that driving in London is a nightmare. Congestion and finding a parking spot are the main contributing factors to this feeling. 51% of the car-owing participants stated that congestion is a huge problem when they drive, and 40% stated that it takes them a lot of time to find a parking space when they use their vehicles.
- Against this background, one out of four car-owning participants stated that they would like to have access to a car without owning one.

Many of the non-car-owners are not in favour of car ownership:

- 87% of them believe that there is no need to own a car in London, regardless of their age or the zone they live in. 78% of them also believe that owning a car is a big hassle.
- 42% stated that they would definitely not buy a car in the future with Millenials leading this car-free lifestyle.

Attitudes towards sharing mobility

Both car-owners and non-car-owners seem to be in favour of car sharing schemes and they find this concept a good alternative to owning a car. Among the survey respondents, car sharing (car clubs) is preferred over peer-to-peer car rental.

- Only 12% of car-owners stated that they are willing to rent their cars to others via a peer-to-peer car rental platform. However, some change their minds when they anticipate that they can have financial benefits from this.
- Younger car-owners (up to 39 years old) and those who live in zones 1-2 are more willing to share their cars via peer-to-peer car rental platforms.
- 48% of non-car owners would be happy to rent someone else's car. However, if they had a car, only 16% of them would be willing to rent out their car to someone else. It is easier for consumers to rent/use others' resources, instead of offering/sharing their own mobility resources.
- 40% of non-car-owning respondents see themselves participating in a car sharing (car club) scheme in the future with Millenials being the most eager to do so.

In general, the idea of car-ownership has been established for almost a century now, and car manufacturers have invested incredible amounts of money to build the "dream" and the status of owning a car. Car sharing schemes have only been around for a decade, yet Londoners seem to have accepted this new concept quite quickly and a significant percentage of them are willing to use them in the future, instead of purchasing their own cars.

Attitudes towards MaaS and car-ownership in the MaaS era

The virtual integration and the bundling of sharing schemes and public transport modes in London together with being able to access of all these modes via a single interface, payment and ticketing

method could further the shift away from private vehicle dependence. Certain factors have the potential to motivate people to subscribe to MaaS while others discourage them.

- 70% of all respondents would be motivated to subscribe if MaaS gave them discounts. This percentage increases to over 80% for the most price sensitive under 30 year olds.
- 50% of respondents would worry about running out of their subscribed amount, while 41% would feel trapped by subscribing to MaaS. The 40-49 age group has the highest proportion of people feeling uneasy about both these aspects.

  Regarding car-ownership in the MaaS era:
- MaaS could be used to introduce more people to public and shared transport modes. Half of the respondents agreed that they would try modes they previously did not use if their MaaS plan included them.
- MaaS has the potential to impact both car-owners' and non-car-owners behaviour. 23% of car owners agree that MaaS would help them depend less on their cars, while a fifth of them would even be willing to sell their cars for unlimited access to car sharing for the next couple of years. Out of non-car-owners, 42% stated that they would delay purchasing a car and 42% stated that they would not purchase a car at all if MaaS were available.

Overall, even though there is still much to learn about MaaS, there are some promising insights to learn. Discounts (that derive from bundling services) could motivate individuals, especially young people, to join MaaS and even use active modes more. MaaS plans can help balance the modal split, by introducing people to modes they previously did not use. Finally, MaaS could support the shift away from the private vehicle ownership by helping car owners depend less on their private vehicles and delay or diminish the need for non-car-owners to purchase these.

Preferences for MaaS plans and their effect on mode choice behaviour

The results show that public transport is an integral part of MaaS, as the vast majority of the participants showed preference towards plans that include public transport modes. Some mode combinations in MaaS plans are more popular than others and the modes included in the plans strongly influence the impact on mode usage.

- The most popular MaaS plan includes public transport, car sharing and taxi with 28% of the respondents choosing such a plan. The top 3 most popular plans all include public transport and taxi and as a result, all these 3 plans increase the usage of public transport and taxi the most.
- 46% of those who use their cars a lot (defined as using it for over 40 car-trips per month) stated that their chosen MaaS plan would increase their public transport usage. This percentage is about 15% higher than those who use their cars less. As a direct contrast, only 6% of those who use their cars a lot stated that their chosen MaaS plan would increase their bike sharing usage, while the percentage is higher for all other car user categories (between 15% and 20%).
- Over 10% of those who use their cars an average amount (11-44 trips/month) would decrease their taxi usage if their chosen MaaS plan was available, while more than 30% of those who use their cars a lot would increase their use of car sharing as a result of their chosen MaaS plan.

In general, public transport is part of all the chosen MaaS plans, showing the importance of integrating the public transport system with the other transport modes available in London. When taxi services are split into traditional taxi and ridehailing in the MaaS plans, users seem to not prefer the traditional taxi services. The initiation of MaaS is expected to positively affect the use of public transport modes. It will also remove a significant number of vehicles from the network with these drivers switching mainly to public transport. An increase in the usage of bike sharing is also expected, as it is a convenient access and egress mode.

MaaS impact on mode switching

To assess the potential mode switching, the participants are split into two categories based on their current mode use profile: 1. Public transport users, and 2. Car users.
Out of those respondents who are currently regular public transport users:

- 34% stated that if MaaS were available, it would most likely have no impact on their public transport usage,
- 29% would most likely substitute part of their public transport usage with taxi,
- 22% would most likely use more public transport,
- 8% stated that MaaS would cause them to substitute part of their public transport use with bike sharing, which shows that MaaS could help in increasing the use of active modes

Breaking this down by residential zone, there seems to be significant differences depending on where the individual lives. When looking at Central London zones (1-2), the most frequently chosen impact is the 'no impact' option, that is, that their public transport usage would not change. Whereas for inner (3-4) and outer (5-7) London zones, substituting public transport with taxis is the most common first choice.

Out of those who are regular car users:

- 25% stated that their car usage would not be affected by MaaS,
  another 25% said they would most likely substitute part of their car trips with tube/rail,
- 20% would substitute their car trips with car sharing,
- 9% with ridehailing and 2% with black cabs if MaaS were available.

According to the survey results, car users living in zone 1 and zone 2 are most likely to give up their car trips and switch to other alternatives when MaaS becomes available.

Wider impact assessment of MaaS

Opportunities for public transport and the public transport authority:

- Demand for public transport could increase as they are bundled with shared and on-demand transport modes offering convenient intermodal and multimodal solutions.
- The ticket sales and the revenue of TfL is expected to increase, as the survey results show that Londoners prefer MaaS plans that definitely include access to public transport modes. Even participants who do not currently use public transport modes, they prefer MaaS plans that include public transport modes.
- An increase in bike sharing sales is also expected as the service is bundled with other transport modes. The inclusion of bike sharing in MaaS plans could motivate Londoners to use it more, especially for short-distance trips or as an access/egress mode.
- MaaS has the potential to improve the network efficiency as it can optimise supply and demand. Specifically in peak hours, the excessive traffic can be redirected to under-utilised routes or other transport modes.
- The single ticketing and payment feature offered by MaaS could speed up the passenger flows in ticketing halls.
- TfL could benefit from the better utilisation of low-demand routes, or from completely removing routes with low demand (as this demand can be allocated to other modes).
- MaaS could remove a significant number of private vehicles off London roads. As such, congestion could be reduced. However, measures should be taken to avoid any rebound effect; for example, an increase in the number of taxi and ridehailing vehicles.

  Economy:
- MaaS can open up new business opportunities as new players enter the transport market. For example, new intermodal routing algorithms that match supply and demand, real-time data processing methods, ticketing and booking solutions, insurance products and legal frameworks are needed.
- The boom of new services that happened when TfL opened part of its data, it is expected to happen again in case TfL opens other key data that is needed for the transport system integration.
-

Environment:

- The shift away from private vehicles is expected to decrease congestion and as a result, improve air-quality.
- MaaS has the potential to shift part of current private car usage to car sharing. The lifespan of shared vehicles is lower than this of private vehicles. By replacing the shared vehicles more often, the age of the vehicle fleet in London would drop and the composition of the fleet would become more sustainable and efficient.
- Fewer cars and more active modes could be on the streets meaning that the noise level could go down.
- Much of on street parking could also be freed, allowing for more pedestrian and retail spaces and an overall better living environment. The potential increased demand for shared vehicles parking spots cannot overpass the demand for private vehicle parking spots.

Londoners:

- MaaS is expected to cut down Londoners' travel cost and travel time, improving their travel experience as well as reducing their dependence on private cars.
- MaaS, in conjunction with the T-Charge scheme, could make sure the 'polluters' pay, not those who are locked-in. T-Charge will charge all car users; however, by introducing MaaS, those who are willing to contribute to air pollution reduction are offered an equally convenient alternative to their cars and can therefore avoid the charge.
- The hassle-free interchanges, the better control over disruptions and the personalised mobility packages will undoubtedly increase the convenience and comfort levels.
- Personalised intermodal real time travel information will also lead to better user experience.

When the era of autonomous vehicle comes, MaaS systems and autonomous vehicles will exist in symbiosis. MaaS users will only need one account to access the autonomous vehicle services supplied by different public transport and shared mobility companies. MaaS, could prepare the transport ecosystem for a smooth transition to autonomous vehicles.

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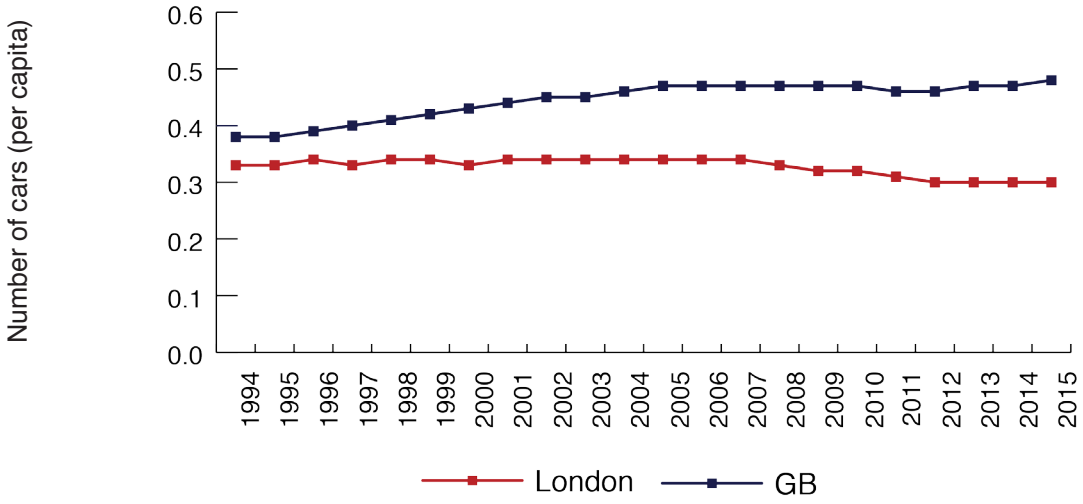
1. Introduction

London has changed substantially over the past two decades, both in terms of transport activity and in terms of economic and social characteristics[1] . The period from 2000 onward saw significant improvements in public transport modes' capacity, quality, coverage and ticketing integration, and the congestion charge zone was introduced. New mobility services, such as vehicle sharing (car clubs, ride sharing/carpooling, bike sharing) and ridehailing schemes have also been initiated offering convenient alternatives to private car usage. At the same time, TfL freely released its key data allowing for hundreds of new products and services to be developed that respond to Londoners' growing demand to access information about transport services via their smartphones. The effect of such efforts has been successfully reflected in a habitual change over the past decade, leading to an increasing number of Londoners willing to take up alternative transport services rather than sticking to their own cars. However, London's traffic congestion is getting worse and the same is happening with air quality[2] . Improvements in vehicle technology alone cannot solve the problem. More vehicles should be taken out of the network if London wants to be a liveable city. New mobility concepts, such as Mobility as a Service (MaaS), that are built on transport system integration, Internet of Things and sharing economy principles could contribute towards this vision.

1.1 Car-ownership in Great Britain and London

Understanding the current situation and trends in car-ownership is an important first step to achieving modal shift away from private vehicles and accelerating the penetration of new mobility services. London historically has had low levels of car ownership compared to the rest of the United Kingdom (UK). Whilst the per capita number of licensed cars in the UK has been increasing gradually over the last 20 years, London's figures remained fairly constant (slightly above 0.3 cars per person) until the global financial crisis in 2008, where the numbers started to slightly decline (Figure 1.1.1). As for the total number of licensed cars, the annual increase in London has also been the slower compared to the increase in the rest of the British areas[3] .

Fig. 1.1.1: Number of licensed cars per capita
(source: Vehicle licensing statistics 1994-2015, DfT)



[1] Clowes, J., 2015. Rising population, falling traffic: why has car ownership fallen while London has prospered? Paper presented at European Transport Conference 2015.

[2] Cookson, G, 2017. Congestion is growing: so how do we tackle it? Available at: http://inrix.com/blog/2017/02/congestion-is-growing-so-how-do-we-tackle-it/

[3] Department for Transport., 2016. Vehicle licensing statistics. Available at: https://www.gov.uk/government/collections/vehicles-statistics

In terms of household car ownership, the statistics show that the proportion of London households owning “No car”, “One car” and “Two or more cars” remained stable between 2005 and 2014 [4] (Figure 1.1.2). More insights can be gained by breaking the results into different household groups based on their socio-demographic characteristics. In 2014, the percentage of London households that owned at least one car increased with household size until stabilising at around 80% for households with 4 or more members (Figure 1.1.3). However, the most noticeable result came from single-member households where only 33% had access to a car; a rate significantly lower than the other groups. A similar trend can also be seen with regards to household income. Only 25% of the poorest households (yearly income below £10,000) had at least one car whereas the rest income groups all had an ownership rate higher than 50%.

Fig. 1.1.2: Number of cars owned by London households (source: London Travel Demand Survey 2005-2014, TfL)

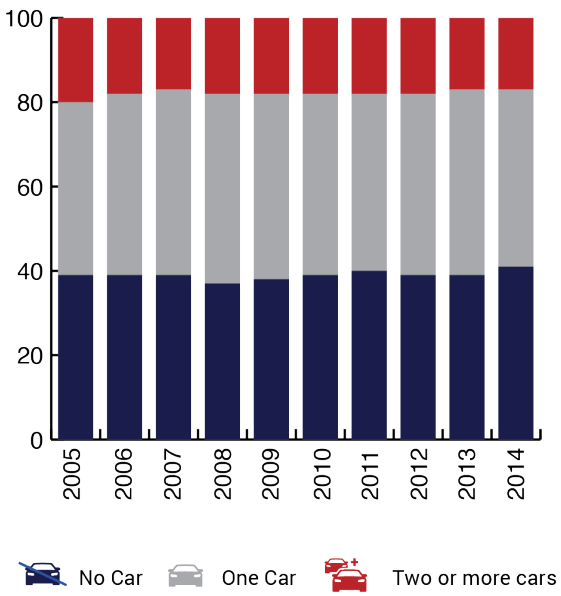
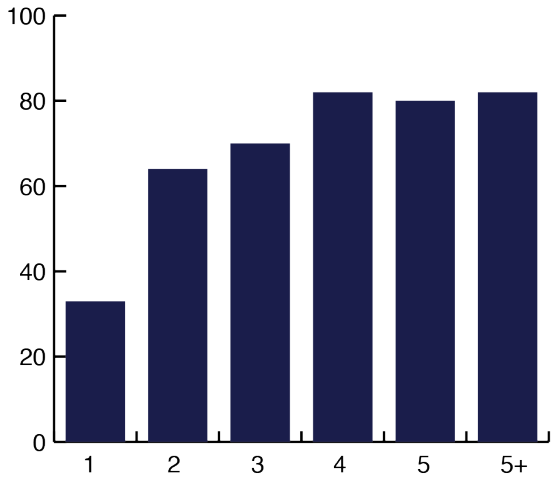


Fig. 1.1.3: Percentage of households owning at least one car by household size (source: London Travel Demand Survey 2014, TfL)



Looking at individual characteristics, in 2014, 48% of the adult males in London were the main users of at least one car; for female adults, the ratio was 37%. In terms of age, 45-59 year olds are most frequently the main users of their household vehicles. With regards to employment status, around 60% of self-employed people (including both full-time and part-time) had frequent access to a car, which was the highest among all employment categories.

From the statistics above, it can be easily seen that Londoners do not have strong dependence on their cars in the current era, especially among some particular socio-demographic groups, such as the Millenials. This has made London into an incubator for new, alternative mobility services, which Londoners have shown great enthusiasm for.

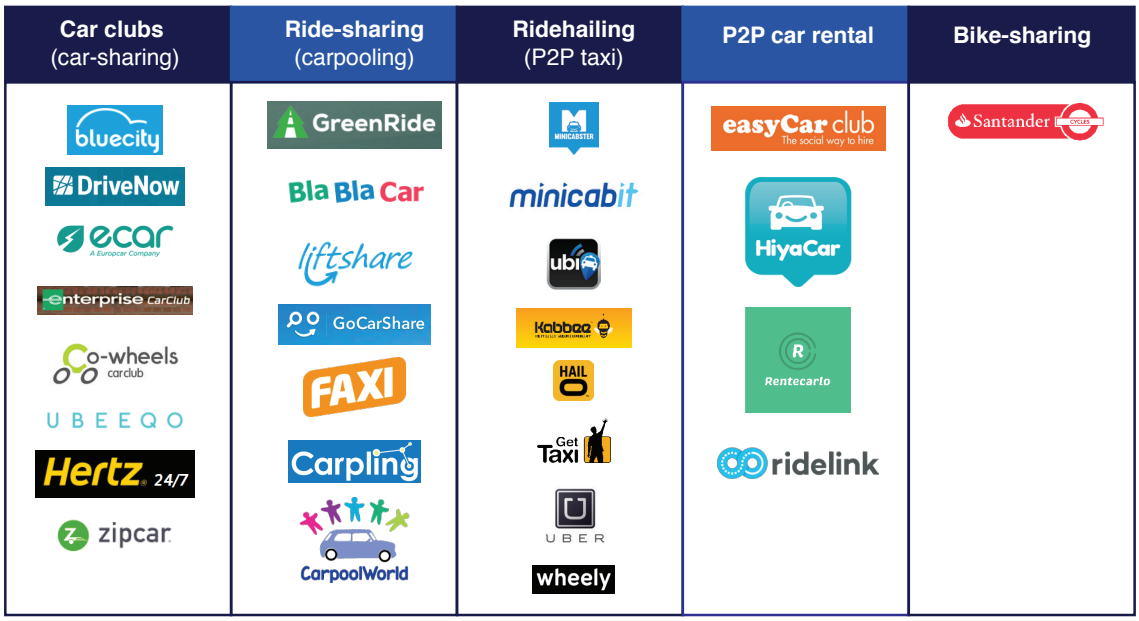
[4] Transport for London., 2016. London Travel Demand Survey.

1.2 New mobility services in London

London is one of the few cities in the world that offers a variety of new mobility services, such as car clubs, peer-to-peer car rental, ridehailing, bike sharing and ride sharing schemes (Figure 1.2.1).

Being either a “Back-to-base” or a “One-way” service, many car club companies have emerged in recent years. The latest figures show that from 2015 to 2016, the number of car club members in London has risen from 155,000 to 186,000 while round-trip members per car have also increased from 66 to 70 people[5]. Meanwhile, the various ride sharing service providers have effectively supported the city of London in surpassing its goal for 2024 (9.3% carpooling rate) way ahead of time[6] (by 2009, the rate had increased to 10.5%). As for the taxi market, a number of ridehailing services (peer-to-peer (P2P) taxi) have come to play. Unlike the traditional black cab and mini cab operators[7], these new services do not own any taxi fleets. Instead, they gather information from partner operators and serve as booking platforms for passengers. Take Uber as an example, by May 2015, the service had been used over 20 million times since its first appearance in London in June 2012[8] . The revolutionary P2P model has also changed car rental industry. Nowadays, besides the traditional car rental companies, individual car owners can also easily rent out their cars via the P2P car rental platforms. This new market has kept growing given the large demand from users, i.e. more than 20% of the UK adults rented a car in 2015[9] . Finally, there has also been a continuous increase in the number of Santander Cycle hires from the 2,180,813 in 2010 to the 10,303,637 in 2016[10] .

Fig. 1.2.1: New mobility services available in London



[5] Carplus., 2016. Carplus auunal survey of car clubs, 2015-2016 London. Available at: https://www.carplus.org.uk/wp-content/uploads/2015/03/Carplus-Annual-Survey-of-Car-Clubs-2015-16-London_Final-2.pdf

[6] Stanford, J., 2015. Update: regional rideshare program. Report to the April 20th 2015 Civic Works Committee Meeting. Available at: https://www.london.ca/newsroom/Documents/RideShare.pdf

[7] Partner operators can be cab companies or independent drivers.

[8] Uber Newsroom., 2015. Cross-country: the growing miles of Uber UK. Available at: https://newsroom.uber.com/uk/cross-country-the-growing-miles-of-uber-uk/

[9] British Vehicle Rental and Leasing Association., 2016. Renting, the big picture. Available at: http://www.bvrla.co.uk/research/article/renting-big-picture

[10] Transport for London., 2017. Number of bicycle hires. Aavailable at: https://files.datapress.com/london/dataset/number-bicycle-hires/2017-04-06T08:41:52.69/tfl-daily-cycle-hires.xls

London could lead a revolution in car use and car ownership over the next decade, by separating/ divorcing the two. It may soon be unnecessary to own a car to enjoy the full benefits of car ownership, due to a combination of continued improvements in public transport, the surge in app-based car hire services, and the growth of car club schemes. However, all these services usually operate in silo and are not integrated with each other. The virtual integration of the available modes in London, is a missing piece of the puzzle that could accelerate the reduction of the number of the vehicles in London's network. This could free up huge amounts of road space for cyclists, pedestrians and traders, slash the cost of mobility, and reduce pollution and emissions.

1.3 The Mobility as a Service concept

The MaaS model covers several concepts that have been extensively discussed in the transportation sector during last decades[11]. These are the integration, interconnectivity and optimization of the transport services, smart and seamless mobility, and sustainability[12]. The model also includes concepts that have recently emerged via the Internet of Things and the sharing economy, such as the term "as a service" and personalisation. Although there are already mobility services that cover these terms (i.e. car sharing, on-demand transport), they usually operate in silo and are not integrated with other modes - especially with public transport. MaaS envisages enabling a co-operative and interconnected single transport market and providing users with hassle free mobility.

Currently, Londoners and in general travellers, have to use numerous tools in order to find information and purchase and access different transport modes. Travellers usually use different journey planning tools to plan their trips. However, most of the existing journey planners do not offer information for intermodal trips (that is, do not combine more than one transport mode – with the exception of walking that is usually the access and egress mode), and only include some of the available transport modes in an area. Furthermore, travellers have to use different payment methods for each transport mode; for example some transport operators only accept cash, others accept cards, smartphone payment or PayPal. Once again, travellers need different tickets/ways to access each mode (public transport modes in London, except bike sharing, are accessed using the same ticket/smartcard, but there is no ticket integration with other transport modes). These are only some of the pain points that deteriorate mobility and hinder intermodality (refers to the use of two or more transport modes in a trip[13]) or multimodality (refers to the use of different modes for different trips) and the choice of sustainable travel behaviours.

The MaaS concept removes many of these user-related pain points. The MaaS provider is an intermediary between transport operators and users. The MaaS provider uses the data that each transport operator offers (via secure APIs), buys capacity from the transport operators and resells it to users. The users only use one interface to find information and choose the preferred transport mode for their trips. The MaaS operator can propose the ideal combination of transport modes to them for each trip by knowing the network conditions in real time (supply side) and the preferences of users (demand side). In other words, the MaaS provider can optimize the supply and the demand.

MaaS envisages not only bridging the gap across transport operators in the same city, but also across different cities and initiates the idea of roaming in the transport sector. Nowadays, it is common for someone to live outside Greater London (usually due to better quality of life or properties prices) and commute to London. At the same time long-distance business trips have been increased, as London is one of the biggest business centres in the world. MaaS providers could cover the travel needs

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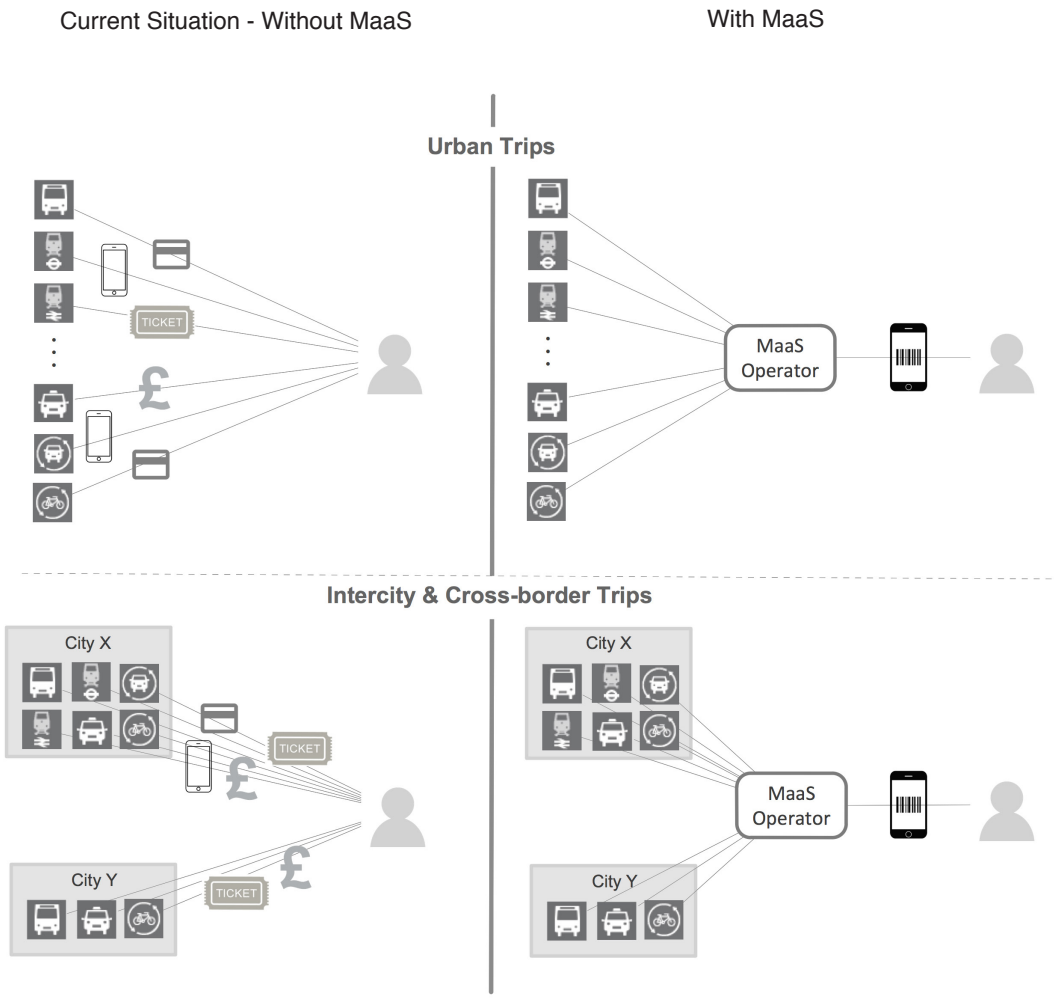
[11] Kamargianni, M., and M. Matyas 2017. The Business Ecosystem of Mobility as a Service. 96th Transportation Research Board (TRB) Annual Meeting, Washington DC, 8-12 January 2017.

[12] Venable, J. R., Pries-Heje, J., Bunker, D., & Russo, N. L. 2010. Creation, Transfer, and Diffusion of Innovation in Organizations and Society: Information Systems Design Science Research for Human Benefit. In J. Pries-Heje, J. Venable, D. Bunker, N. L. Russo, & J. I. DeGross (Eds.), Human Benefit through the Diffusion of Information Systems Design Science Research: 1–10. Berlin: Springer.

[13] Berwick, D. M. 2003. Disseminating Innovations in Health Care. JAMA, 289(15):1969–1975.

of their customers not only in their home-city, but anywhere around the world where they operate. This is already a feature that some of the on-demand and car sharing services offer. For example, a user can use/access ridehailing services in all the cities where the companies operate by using the same app and by having exactly the same user account and payment details. Figure 1.3.1 depicts the current situation for urban and intercity trips from a user's point of view and the way transport services could be accessed when a MaaS service is available.

Fig. 1.3.1: Without and with MaaS from a traveller's point of view



Via MaaS, travellers can purchase mobility services that are provided by the same or different mobility operators by using just one platform and a single payment (Figure 1.3.1). The MaaS services, depending on their business model, usually provide a dynamic multiservice journey planner (offering combinations of the different transport modes available for an area, such as car club, car rental, underground, rail, bus, bike sharing, taxi), a booking system, a single payment method (single payment for all transport modes), and real time information[14]. MaaS users can use the service either as Pay-As-You-Go or they can purchase mobility packages based on their or their households' needs.

[14] Kamargianni, M., Matyas, M., Li, W., Schäfer, A., 2015. Feasibility Study for Mobility as a Service Concept for London. UCL Energy Institute report, Prepared for the UK Department for Transport

1.4 Objectives of the report

MaaS may lead to significant changes in Londoners' car ownership and mode choice behaviour as they will be offered an opportunity to enjoy door-to-door seamless mobility without the need to own a car. As a result, wider benefits would also be expected such as less congestion and better air quality. Although there are a lot of ongoing discussions about MaaS, so far there is no quantified evidence about Londoners' preferences for sharing mobility and MaaS products, and the impact MaaS could have on mode choice behaviour and modal shift. Against this background the objectives of this report are to provide to the transport authority of the city insights about:

- citizens' attitudes towards owning and using a car in London;
- citizens' willingness to shift from vehicle ownership to vehicle usership;
- Londoners' attitudes towards Mobility as a Service and their preferences for MaaS products;
- potential modal shifts in the MaaS era and the opportunities that could arise for the public transport system of the city; and
- the impact MaaS could have on the society, economy, environment and air-quality of the city.

1.5 Survey and sample

Since there is no existing dataset about Londoners' travel behaviour, choices, attitudes and perceptions about new mobility services, and preferences towards MaaS, a survey has been designed specifically to collect information about the aforementioned topics. The survey is called London Mobility Survey (LMS)[15] and it has been designed by the MaaSLab[16] at University College London (UCL). LMS has been developed using a smartphone based travel survey tool, the Future Mobility Sensing[17] (FMS). LMS incorporates several parts of the London Travel Demand Survey to allow for comparisons, while it has been enhanced with additional detailed questions about usage of new mobility services (i.e. car clubs, ridehailing etc.), and costs of car-ownership. LMS consists of 3 steps:

1. The pre-questionnaire, where participants are asked about their socio-demographic and mobility tool ownership characteristics along with their attitudes towards private vehicle ownership and sharing mobility.

2. The tracking app; after the completion of Step 1, participants are asked to download the app on their smartphones and track their activities for 7 days. During the tracking participants are required to log back in the LMS webpage and validate their activities and answer some additional questions.

3. The exit section; when the 7-day tracking and validation is complete, respondents are shown with their Mobility Record (an aggregated summary of the number of trips, duration, travel time and cost broken down by each transport mode). Based on their Mobility Record hypothetical MaaS monthly packages (stated preference experiments) are generated including several combinations and amounts of the available transport modes in London[18]. Participants are asked to choose the MaaS monthly plan that better fit to their needs. For each MaaS package the participants choose, they are asked to indicate potential changes in mode use and potential mode shifts. Finally, a number of questions with regards to attitudes towards MaaS products are asked.

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[15] https://london.fmsensing.com/general

[16] https://www.maaslab.org

[17] https://its.mit.edu/future-mobility-sensing

[18] Matyas, M. and Kamargianni, M., 2017. Stated preference design for exploring demand for "Mobility as a Service" plans. Paper presented at the 5th International Choice Modelling Conference, Cape Town, South Africa, 3-5 April, 2017.

For the purpose of this report, the sample used consists of 338 individuals. These 338 individuals have completed the first step of the LMS, and their responses are used for the analyses in Sections 2 and 3 of this report. For the analyses in Sections 4, 5 and 6, a sub-sample is used consisting of 119 individuals who successfully completed all the three steps of LMS. The sample was randomly collected via the Work.Shop.Play panel of Exterion Media. This random sample consists of individuals who live or work in Greater London. Due to the fact that LMS is a smartphone based survey tool, only people with smartphones and those over 18 were eligible for the study[19]. The data used in this report was collected between November 2016 and February 2017 (excluding the holidays). For details about the sample characteristics please see Appendix A.

1.6 Structure of the report

The rest of the report is structured as follows:

- **Section 2** elaborates on attitudes towards owning and driving a car in London;
- **Section 3** presents Londoners' attitudes and willingness to use sharing mobility services;
- **Section 4** offers insights about Londoners' attitudes and preferences towards Mobility as a Service;
- **Section 5** presents the first quantified evidence about MaaS products and their effect on mode choice behaviour; and
- **Section 6** provides insights about potential modal shifts in case MaaS is available in London, and assesses the consequences these could have on the public transport system, society, the environment, the economy, and the air-quality of the city.

[19] Four out of five adults in the UK have a smartphone. Among 18-44 year olds, smartphone adoption is higher than 91% (Deloitte, 2016. Global Consumer Survey: UK Cut. Available at: https://www.deloitte.co.uk/mobileuk/)

2. Londoners' attitudes towards owning and using a car

London, which has pioneered congestion charging and has a well-integrated public transport system, has led the move away from cars over the past decade, with a significant number of car commuters have switched to other forms of transport[20]. However, the number of private vehicles on the transport network still remains a huge problem for the city. Understanding how drivers feel and the pain points they face while driving is an important first step for designing services that can move them away from owning or using a private car. This section focuses on analyzing and comparing car-owners and non-car-owners' attitudes towards owning and using a car in London. The cost of owning a vehicle in London is also calculated taking also into account parking and congestion charging expenses that are usually excluded from the car-ownership cost. 75% of the participants in the survey have a driving license, while 53% of the participant households own at least one vehicle.

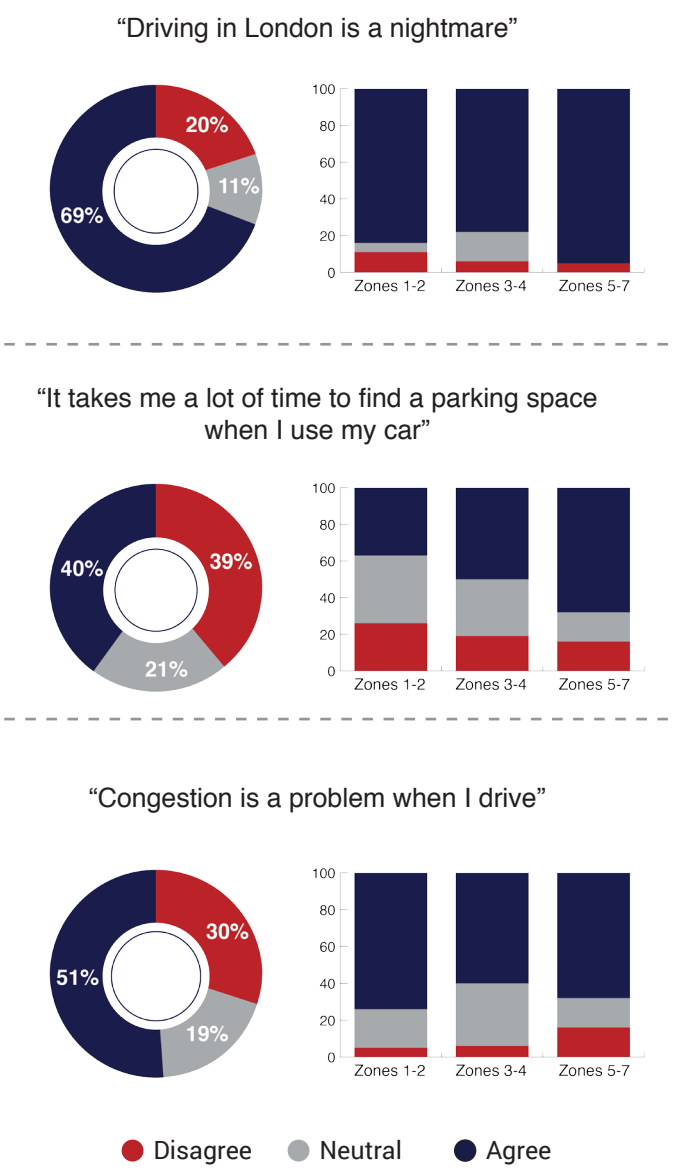
2.1 Car-owners' attitudes towards driving in London

According to many of the survey respondents, owning and driving a car in Greater London does not make their life easier. 69% of car-owning participants agreed to the statement "Driving in London is a nightmare" (Figure 2.1.1). This attitude remains fairly constant across all the residential zones. However, those who live in zones 5-7 have the highest percentage (95%) of individuals agreeing with this statement.

Recent findings indicate that London is the most congested European city, with the capital's drivers spending an average of 96 hours stuck in traffic in 2016[21]. This is reflected in this survey as well, with 51% of the car-owners stating that congestion is a problem when they drive (Figure 2.1.1). Those who live in zones 1-2 seem to face the biggest congestion problems as 74% of them agree with this statement.

Another pain point of owning and driving a car in London is finding a parking space. 40% of the car-owning participants declared that it takes them a lot of time to find a parking space when they use their vehicles (Figure 2.1.1). It seems that the time to find a parking space varies considerably depending on residential zone. Only 37% of the car-owning participants who live in zone 1 agreed with this statement, while the same number for those living in zones 5-7 is 68% (31% difference).

Fig. 2.1.1: Attitudes towards driving in London



[20] http://content.tfl.gov.uk/travel-in-london-report-8.pdf

[21] INRIX., 2016. INRIX reveals congestion at the UK's worst traffic hotspots to cost drivers £62 billion over the next decade. Available at: http://inrix.com/press-releases/inrix-reveals-congestion-at-the-uks-worst-traffic-hotspots-to-cost-drivers-62-billion-over-the-next-decade/

2.2 Car-owners' attitudes towards owning a car in London

Apart from the capital cost needed to purchase it, owning a car also entails a number of other expenses, such as road tax (VED), insurance, fuel, parking, MOT and other maintenance costs. To add to this, car-owners in London have some other costs, for example congestion charging and higher car-insurance contracts as the risks of a collision or a car crime (such as theft of- or from a vehicle, uninsured driving or attempts at 'cash for crash' fraud) is much higher[22] than in other areas.

Tracking all the aforementioned costs to calculate the exact cost of car-ownership is quite difficult for the owners, as each service is usually paid at different points in time. The average cost of ownership for the first vehicle in each household in our sample is £233.5 per month. For the calculation of this, we took into account the costs presented in Table 1, while the maintenance and MOT costs were excluded because these costs depend on the age of the car and vary across the years; by adding these costs, the cost of ownership is expected to be higher.

Table 1: Cost of car-ownership for the first vehicle of the household

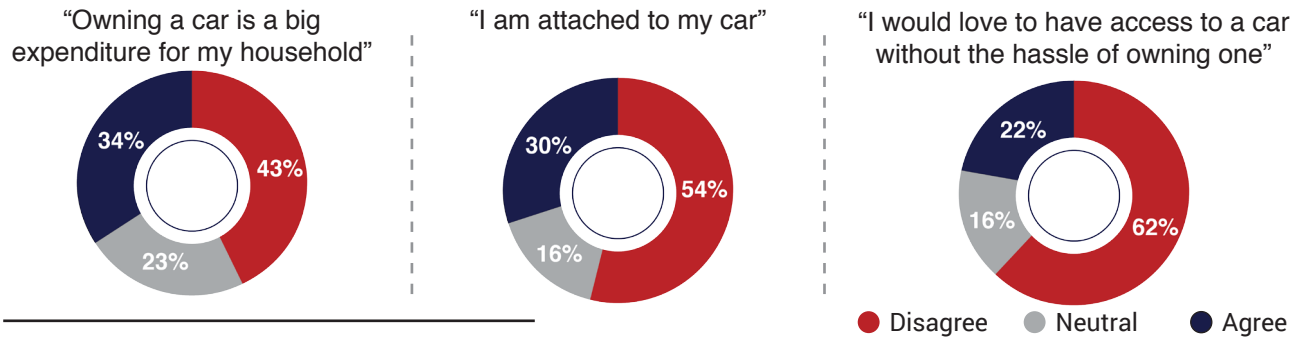
Cost	Per Month	Per Year
Average fuel cost	£70.5	£846
Average VED (road tax):	£11.8	£142.6
Average insurance cost	£75.8	£909.6
Average cost of resident parking permit for first vehicle	£8.1	£97.8
Additional parking costs for the first vehicle	£29.8	£357.6
Average cost of entering Congestion Charging Zone	£37.5	£450
	£233.5	**£2,802**

Regarding their attitudes towards costs of car-ownership, 34% of respondents believe that owning a car is a big expenditure for their household (Figure 2.2.1). Most of the participants who agree with this statement live in zones 1-2, with 48% of them fully agreeing that owning a car is costly for their household. One of the reasons that car-ownership is more expensive in these zones is the costs they have to pay for parking.

Studies have shown, that some car-owners tend to personify their cars to the point that the relationship with them mirrors relationships with living beings in their lives[23]. In addition to the large financial investment, a car can become a significant emotional investment – it is there with them for major milestones in their lives like weddings, babies and graduations and it is literally the 'vehicle' that makes being physically present in these moments possible. For Londoners this seems to be less true, with only 30% of the participants stating that they are attached to their car, while 54% completely disagreeing with this statement (Figure 2.2.1). The majority of those who feel attached to their car belong to older age groups (over 40 years old), while most of the Millenials do not share this sentiment.

Most car-owning participants do not like the idea of just having access to a car without owning it (Figure 2.2.1). 62% of them disagree with the statement "I would love to have access to a car without the hassle of owning one". However, 22% agree with this statement, which means there is potential

Fig. 2.2.1: Car-owners' attitudes towards owning a car



[22] Confused., 2016. Car insurance price index. Available at: https://azcdubmedia.azureedge.net/media/themes/fab-four/Price-index/layout/2016Q4/Confused-com-car-insurance-price-index-Q4-2016.pdf

[23] Carriere, N., 2013. Survey reveals relationships with cars mimic relationships with people. Available at: http://press.autotrader.com/2013-06-04-Survey-Reveals-Relationships-with-Cars-Mimic-Relationships-with-People

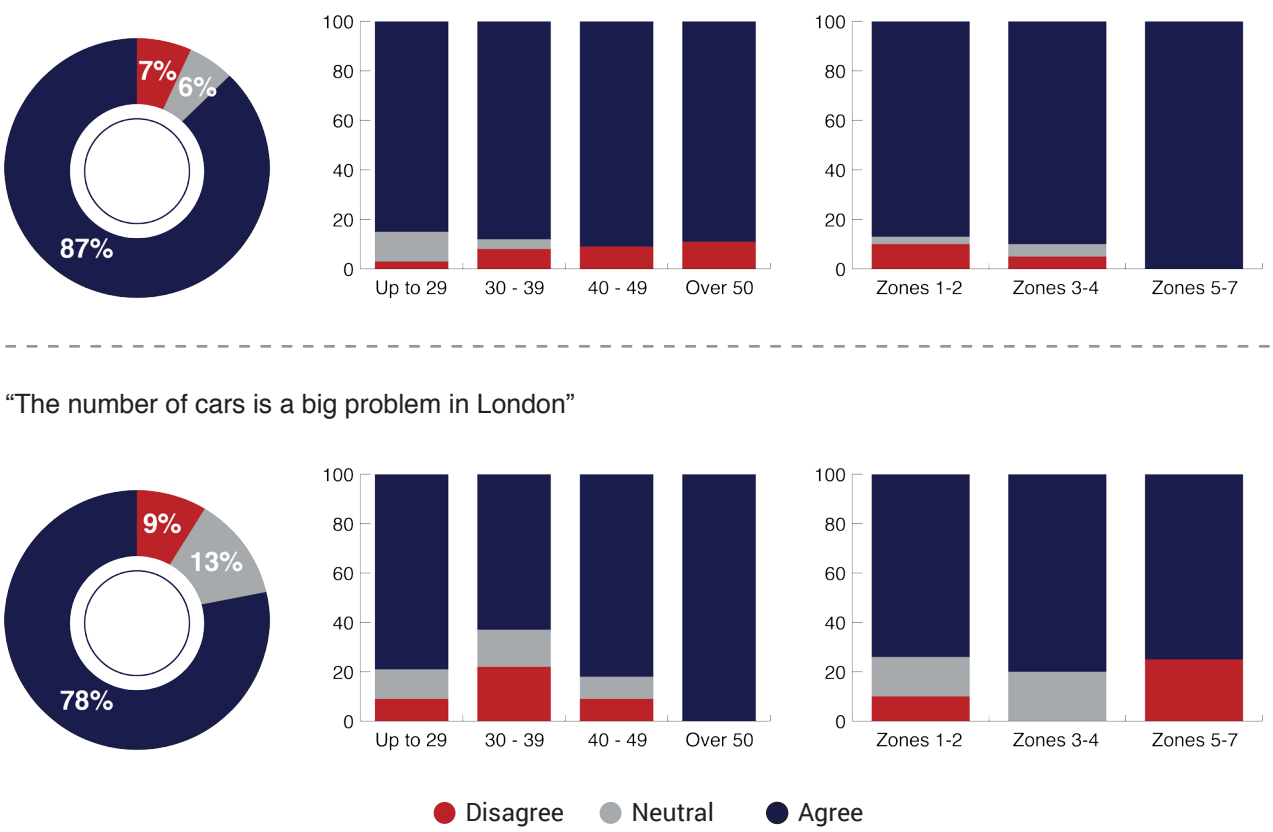
2.3 Non-car-owners' attitudes towards owning a vehicle in London

London is a city with many characteristics that could enable a car-free lifestyle. It has a very good public transport system with extensive coverage as well as several other options, such as car sharing and ridehailing services. 47% of the participants in this survey do not own a vehicle and in most cases this is a conscious choice.

The vast majority (87%) of non-car-owning survey respondents believe that there is no need to own a car in London regardless of their age or the zone they live (Figure 2.3.1). The public transport system of the capital satisfies their travel needs and they usually use active transport or ridehailing services when public transport is not an option.

78% of non-car-owners also believe that the number of cars is a big problem for London (Figure 2.3.1). 100% of respondents over 50 years old, while only 63% of those between 30 to 39 years old agree with this statement. Although private car-ownership has decreased during the past years, the roads of the capital are still congested. One of the reasons is that the number of the vans and trucks entering central London has significantly increased due to deliveries and construction work taking place in the city.

Fig. 2.3.1: Non-car-owners' attitudes towards owning a car in London



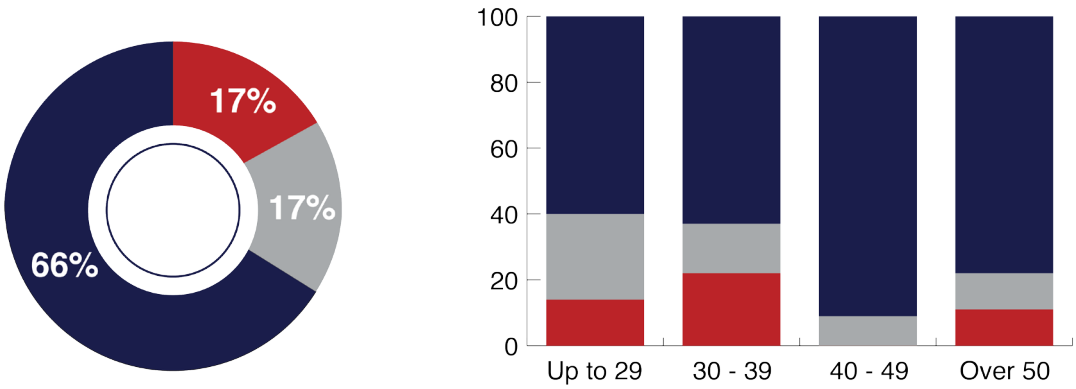
Most of the non-car-owning participants believe that owning a car is a big hassle (72%). The age group where the highest proportion of respondents agree with this statement is the 40-49 year olds (Figure 2.3.2). This attitude remains fairly consistent across residential areas, genders and ethnicity.

66% of the non-car-owners agree that a car is just a mean to go from A to B and there is no need to own one (Figure 2.3.2). Those over 40 years old seem to agree more to this statement compared to their younger peers.

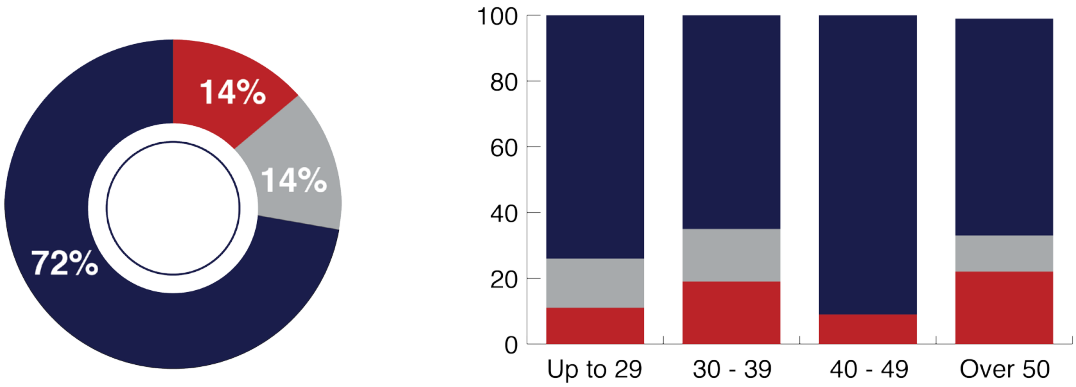
Nowadays the number of services that offer the opportunity to use a car without owning it is constantly increasing. London offers a variety of such services and 45% of the participants agree that there is no need to own a car in the “as a service” era we live (Figure 2.3.2). Given that it takes years and in some occasions, generations for a behaviour to change, this is a very encouraging finding indicating that people have started to realize that car-ownership does not fit to our era. When analyzing the scores for each age group, those who disagree the most with this statement are the youngest participants (40%; up to 29 years old).

Fig. 2.3.2: Non-car-owners’ attitudes towards owning a car

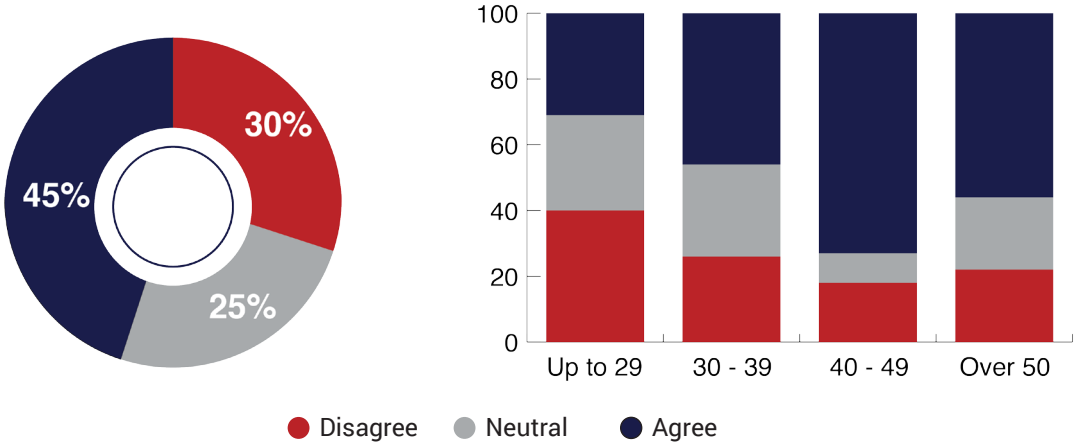
“I just want to go from A to B; there is no need to own a car”



“Owning a car is a big hassle”



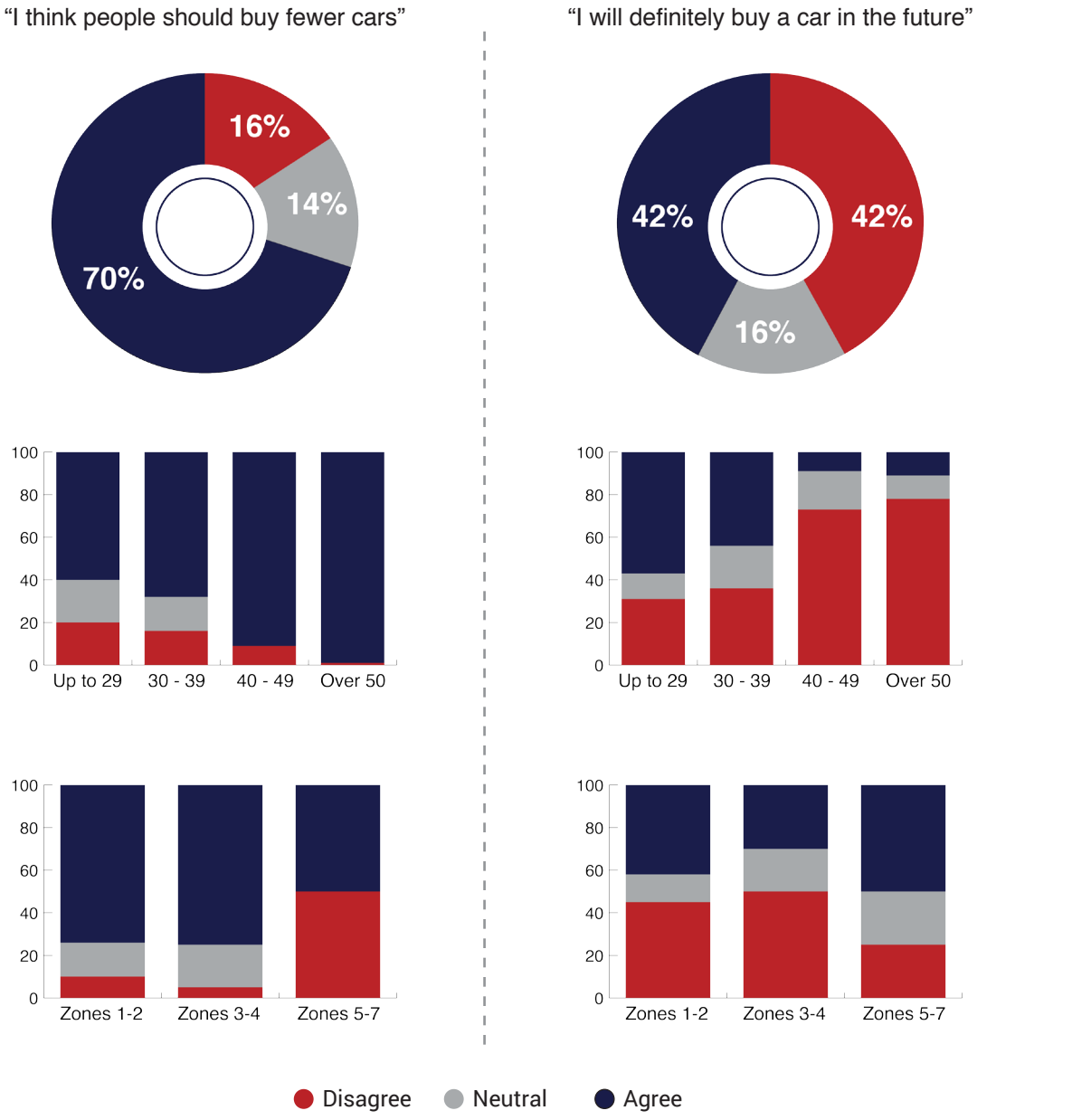
“There is no need to own a car in the “as a service” era we live”



In general, 70% of non-car-owning participants believe that people should buy fewer cars. By comparing the answers of each age group, it can be seen that once again the youngest participants disagree more with this statement while almost all the over 50s agree with it (Figure 2.3.3). A noticeable difference also exists across the residential zones, with only 10% from zones 1-2 and 5% from zones 3-4 disagreeing with this statement, while the percentage of those who disagree in zones 5-7 is 50%.

When the current non-car-owners where asked about their future plans regarding purchasing a vehicle, 42% agreed and 42% disagreed with the statement "I will definitely buy a car in the future" (Figure 2.3.3). The younger age groups are those who agree the most with this statement; 57% of those under 29 and 44% of those between 30 and 39 declare that they will purchase a car in the future. This answer may be partially motivated by this generation thinking about having children, settling down or moving to suburban areas outside London in the future. However, it can be seen, that as the age increases a higher proportion of participants agree with the fact that they will not purchase a vehicle. Probably the more years they live in London the more they realize that there is no need to own a vehicle in the UK capital.

Fig. 2.3.3: Non-car-owners' attitudes towards purchasing a car



Highlights

- The average cost of ownership for the first vehicle is £233.5 per month / £2,802 per year (excluding maintenance and MOT costs).
- 34% of car-ownning participants believe that owning a car is a big expenditure for their household.
- 22% of car-owners are in favour of just having access to a car without the hassle of owning one.
- Car-owners seem to face several pain points while driving:
    - 69% of the car-owning participants claimed that driving in London is a nightmare. This attitude remains fairly constant across all the residential zones with zones 5-7 having the highest percentage (95%) of people agreeing with this statement.
    - 51% of car-owners stated that congestion is a problem when they drive. Those who live in zones 1-2 seem to face the biggest congestion problems as 74% of them agree with this statement.
    - 40% of the car-owning participants declared that it takes them a lot of time to find a parking space when they use their vehicles.

- The survey results suggest, that the vast majority (87%) of non-car-owners believe that there is no need to own a car in London, regardless of their age or the zone they live in.
- 78% of non-car-owners also believe that the number of cars is a big problem for the UK capital.
- 72% of non-car-owning respondents believe that owning a car is a big hassle.
- 70% of the non-car-owning participants believe that people should buy fewer cars.
- 42% of non-car-owners stated that they will definitely not buy a car in the future. Millenials are those who agree the most with this statement.

In general, owning a vehicle in London is a substantial expense for households. Instead of making their lives easier, it adds many pain points to their daily life as they loose time stuck in traffic or trying to find a parking space. That's why the great majority of the participants stated that driving in London is a nightmare and 22% of them would like to have access to a car without owning one. The survey results indicate that non-car-owners believe that there is no need to own a car in London as the city offers several alternatives to car. As such, 42% of them stated that they are not planning to purchase a vehicle in the future with Millenials leading this car-free lifestyle.

3. Londoners' attitudes towards sharing mobility

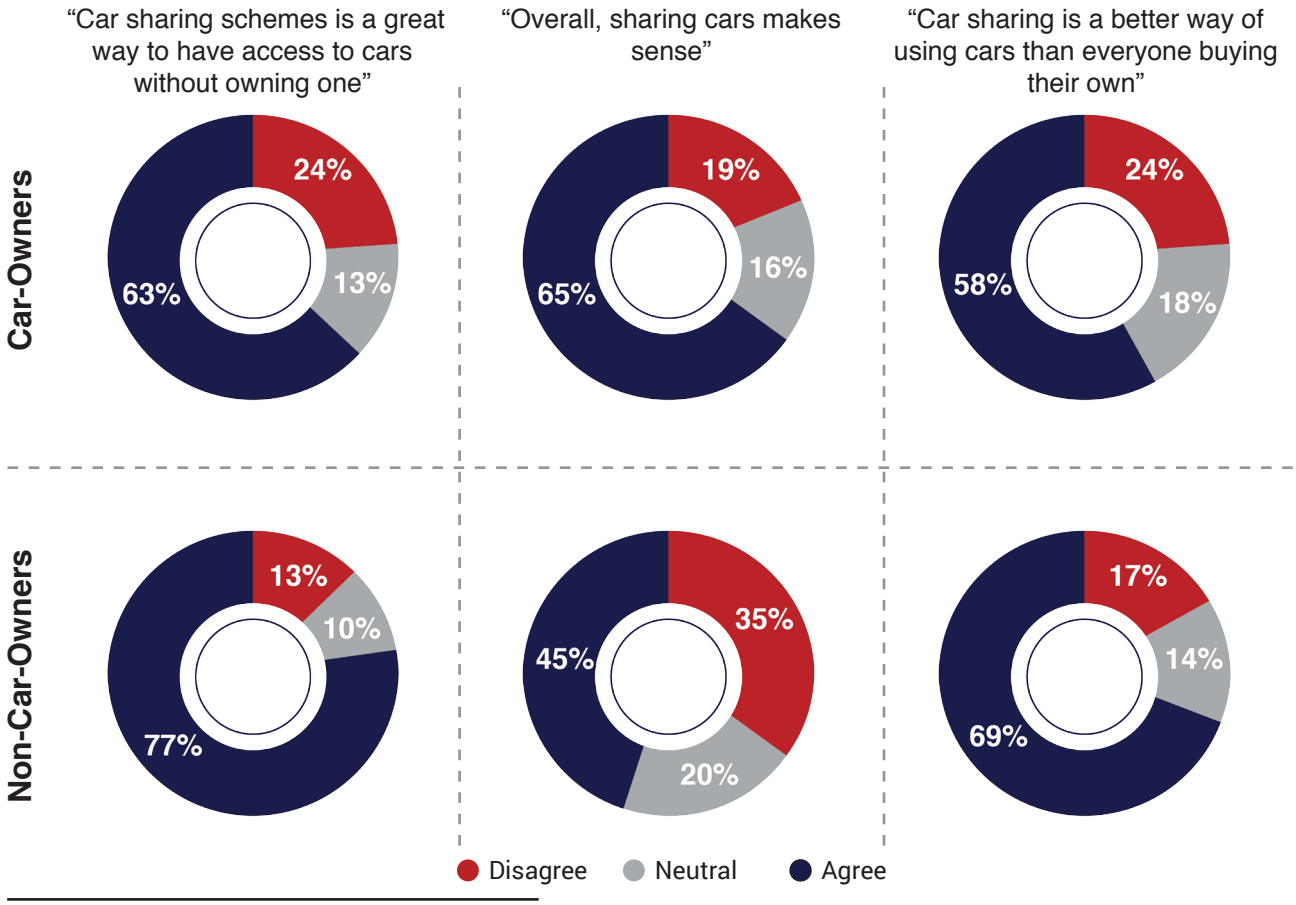
In the coming years, London faces challenges of population growth and increased congestion which will threaten air quality and the environment. Shared mobility provides a cost-effective and flexible alternative to owning a car, and can help tackle these challenges. Joining a shared mobility scheme provides the convenience of owning a car without the hassle and costs of repairs, servicing or parking. Members can book cars locally for just an hour, up to a whole weekend, or longer. But how open are Londoners to these sharing mobility concepts? This section focuses on Londoners attitudes towards car sharing schemes and peer-to-peer rental.

3.1 Comparing car-owners and non-car-owners' attitudes towards shared mobility

Car sharing schemes have started expanding in the UK capital, with more than 10 schemes currently available in London. 80% of the participants in this survey are aware of the car sharing (car clubs) concept[24], while 10% of the participants are members of such a scheme.

In general, both car-owners and non-car-owners seem to be in favour of car sharing (Figure 3.1.1). The majority of both car-owning (63%) and non-car-owning (65%) participants agree that car sharing is a great way to have access to cars without owning one. 77% of non-car-owners compared to 58% of car-owners agree with the statement that "Overall, sharing cars makes sense". A big difference can be seen regarding the statement "Car sharing is a better way of using cars than everyone buying their own", with 69% of non-car-owners agreeing with this, while only 45% of car owners. However, the percentage for car-owners is still quite high, indicating that almost half of the car-owners anticipate that sharing is better than owning.

Fig. 3.1.1: Car-owners and non-car-owners' attitudes towards car sharing schemes



[24] To avoid any misunderstanding, the car sharing (car club) concept was defined before asking the survey participants if they are aware of the availability of such a concept in their city.

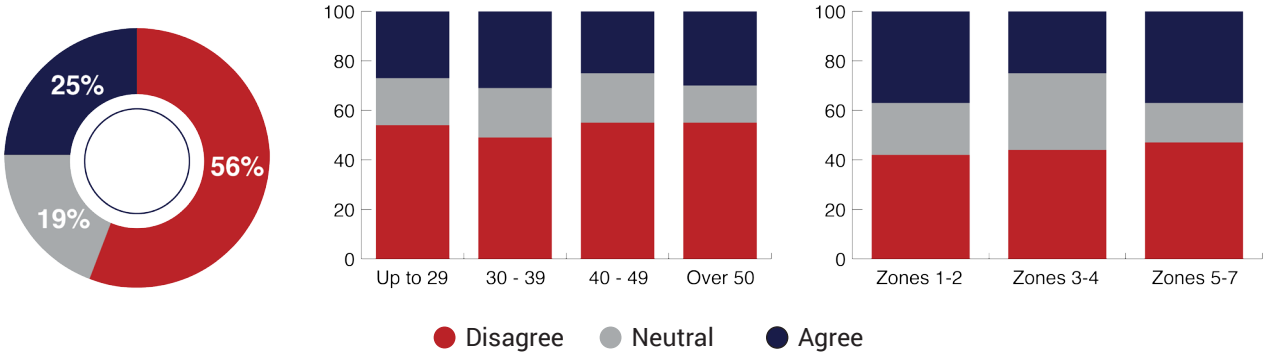
3.2 Car-owners attitudes towards sharing mobility resources

Focusing now only on car-owners, we explore their attitudes towards shared mobility and their willingness to shift from consumers to "prosumers", in other words to provide/rent their vehicles to others via peer-to-peer car rental platforms.

25% of car-owning participants agree that more people should rent their cars to others when they are not using them (Figure 3.2.1). The differences across age groups are not that significant, but the 30-39 age group has the highest fraction of respondents who agree with this statement compared to the other groups. Looking at the responses based on the residential zone, those who live in Central (1-2) and Outer (5-7) London zones have a higher percentage of people who support this statement.

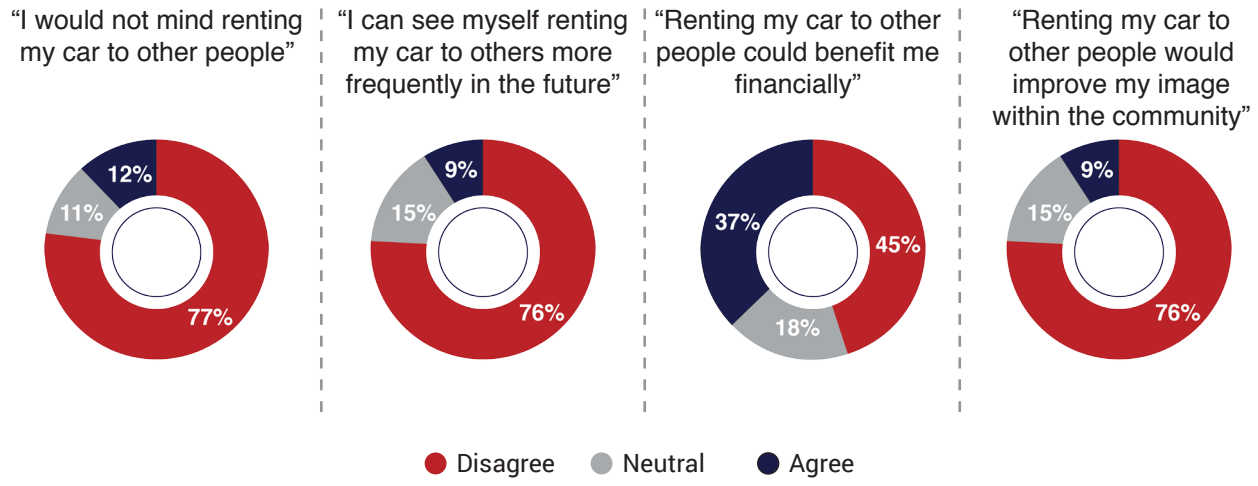
Fig. 3.2.1: Car-owners' attitudes towards sharing cars

"More people should rent their cars to other people when they are not using it"



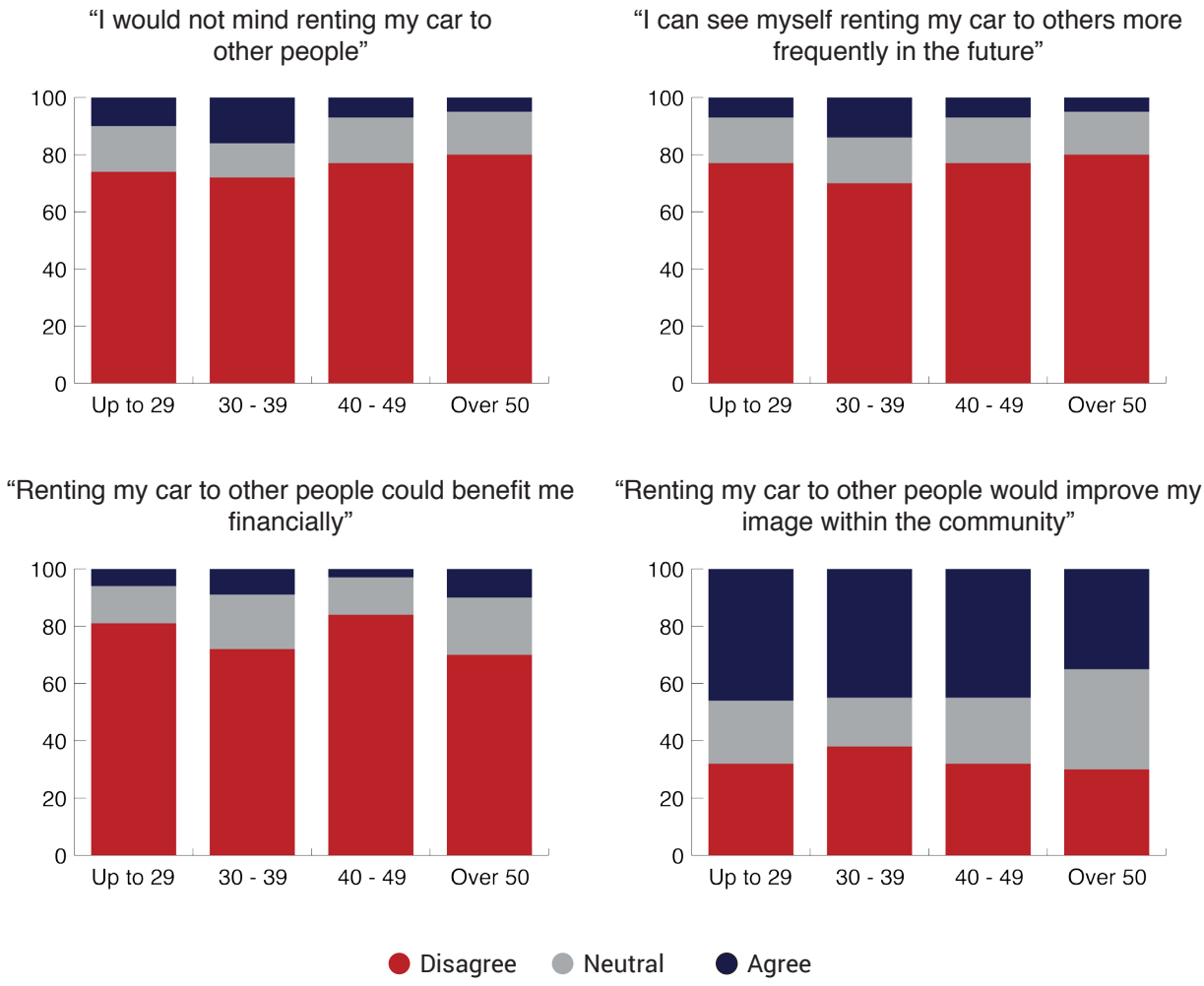
When the statements in the survey become more personal about sharing their own cars, the majority of car-owners seem unwilling to share/rent them to other people (Figure 3.2.2). 77% of car-owning respondents disagree with the statement "I would not mind renting my car to other people". 76% of car-owners cannot see themselves renting their cars to others in the future. However, 12% would not mind renting their car to others, showing that there is a market for peer-to-peer sharing (peer-to-peer car rental). Improving their image within the community does not motivate car owners to rent their cars to others as 76% of them also disagree with this statement. The only incentive that can make car-owners consider offering their vehicles on peer-to-peer car rental platforms is a financial one. 37% of the participants agree with the fact that "Renting my car to other people could benefit me financially".

Fig. 3.2.2: Car-owners' attitudes towards renting their vehicles to others



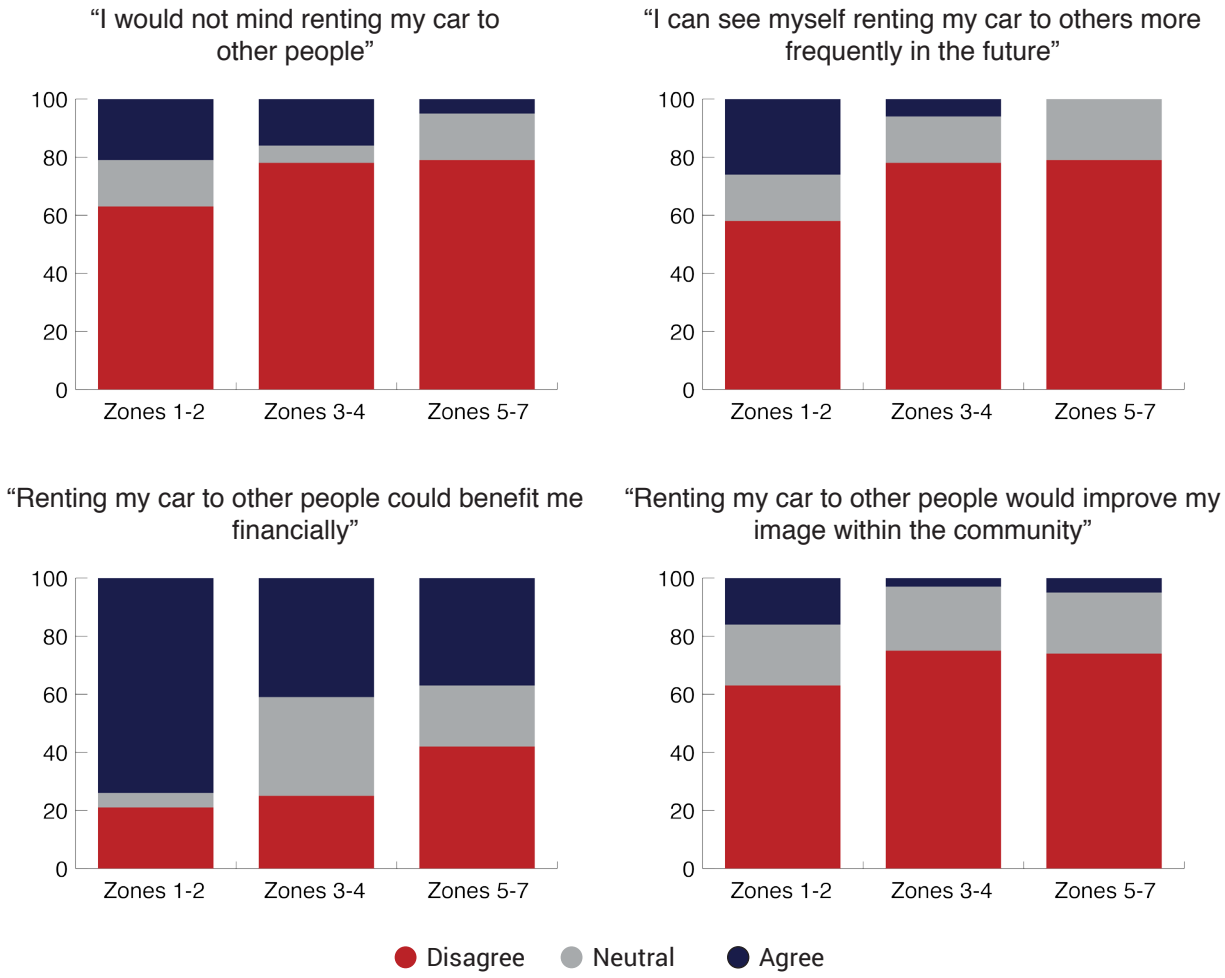
By analysing the aforementioned statements based on the age groups, there are no significant differences (Figure 3.2.3). The age group that seems most willing to rent their cars to other people are 30 to 39 year olds, with 16% of them agreeing with this statement. In addition, 14% of them agree that they can see themselves renting their cars more frequent in the future, while in contrast, only 5% of those over 50 agree with this statement. The financial benefits of renting their cars to other people seem to be more appealing to the age groups up to 49 years old; 46% of the youngest age group, 45% of the 30 to 39 and 45% of the 40 to 49 age groups agree that renting their car could benefit them financially.

Fig. 3.2.3: Car-owners' attitudes towards renting their vehicles to others by age groups



Attitudes towards sharing vehicles vary across residential zones (Figure 3.2.4). Car-owners who live in Central London (zones 1-2) seem to be more open to sharing their vehicles compared to those living further away from the centre. 21% of those who live in zones 1-2 agree with the statement "I would not mind renting my car to other people". 26% of them even see themselves renting their vehicles to other people in the future. 16% of them agree that renting their cars to other people would improve their image within the community, compared to 3% and 5% of those who live in zones 3-4 and 5-7 respectively. A big difference is noticed regarding the financial benefits that could be derived by renting their vehicles to other people. 74% of residents in zones 1-2, compared to 41% of zones 3-4 residents and 37% of zones 5-7 residents, believe that offering their cars to peer-to-peer car rental schemes could benefit them financially.

Fig. 3.2.4: Car-owners' attitudes towards renting their vehicles to others by residential zone



3.3 Non-car-owners attitudes towards shared mobility

Below the attitudes of non-car-owning participants towards shared mobility are presented (Figure 3.3.1). 16% of non-car-owners stated that if they had a car, they would be willing to rent it to other people, while 72% disagreed with this statement. Those who would be more willing to share their mobility resources are under 49 years old and most of them live in zones 1-4.

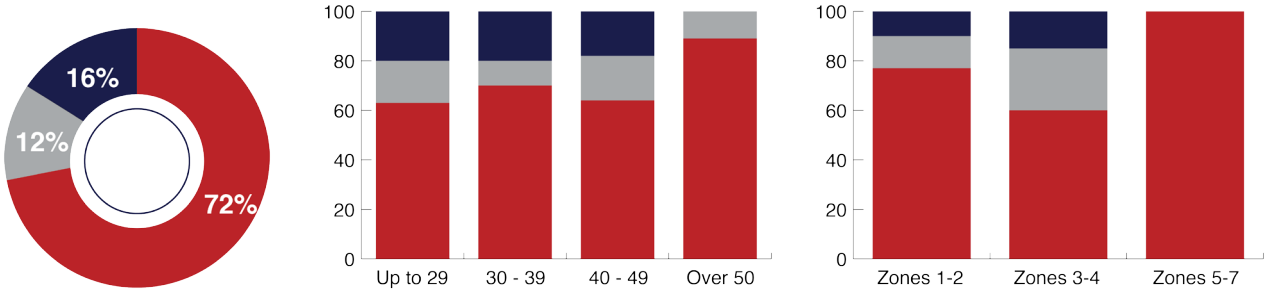
Although only 16% of participants agreed that if they had a car they would be happy to rent it to other people, 48% of them stated that they would be happy to rent someone else's car if they needed one. The majority of those who agree with this belong to the 30-39 year old group (64%), followed by the 40 to 49 age group (55%) and the youngest age group (46%). In addition, those who live in zones 1-2 seem more willing to rent someone else's car (58%), followed by those who live in zones 3-4 (55%).

Regarding car sharing/car clubs, 36% of non-car-owning respondents believe that sharing a car instead of owning their own is a good option for them. The groups with the highest fraction of people agreeing with this statement are the Millenials (up to 39 years old) and those who live in Central London. As we move further out from the centre, lower percentages of people agree with this statement.

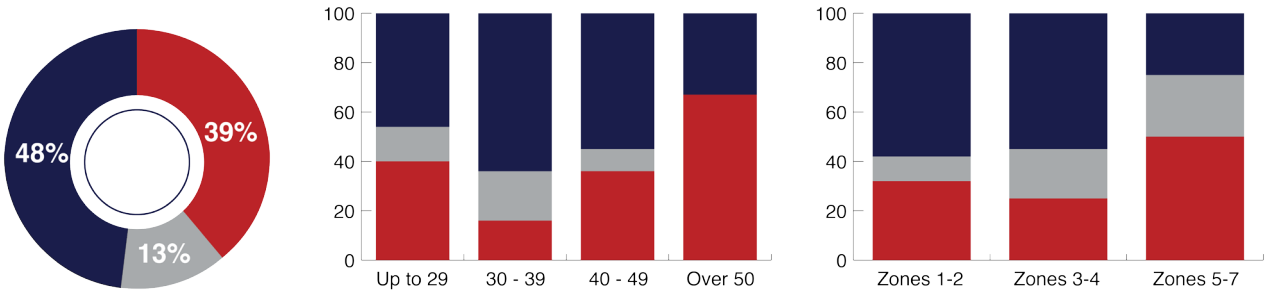
Finally, 40% of non-car-owners stated that they would likely participate in a car sharing scheme in the future. Millenials are most willing to participate in car sharing, while a much lower percentage of people over 40 would be willing to do so. Those whole live in zones 1-4 are more likely to participate in such schemes than those living in Outer London.

Fig. 3.3.1: Car-owners' attitudes towards renting their vehicles to others by residential zone

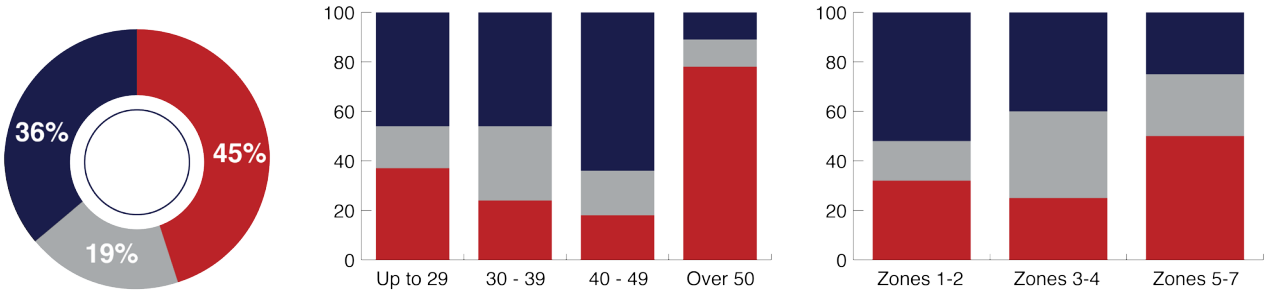
"If I had a car I would happily rent it to other people"



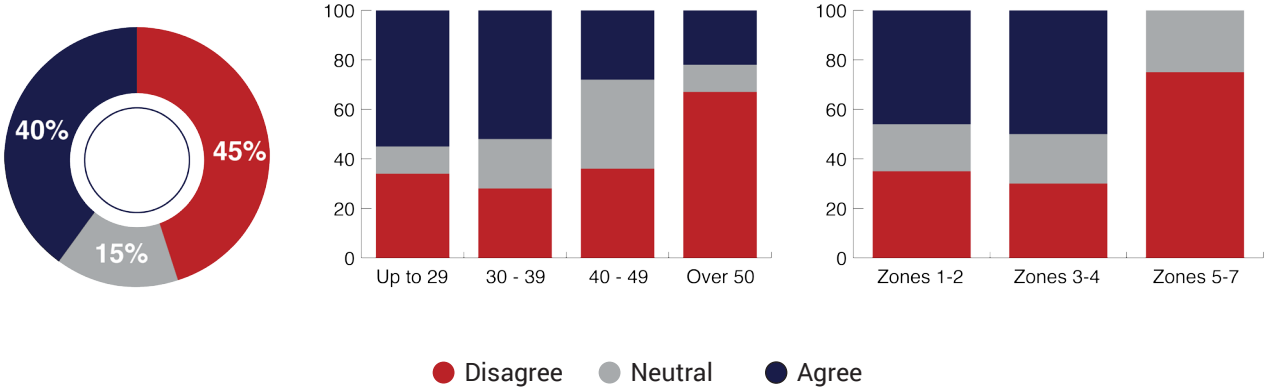
"I would happily rent someone's car if I needed a car"



"Sharing a car instead of owning my own is a good option for me"



"I will likely participate in car sharing in the future"



Highlights

- Survey results indicate that both car-owners and non-car-owners seem to be in favour of car sharing schemes and they find this concept a good alternative to owning a car.

- Respondents prefer car sharing (car clubs) over peer-to-peer car rental.

  - Only 12% of car-owners are willing to rent their cars to others via a peer-to-peer car rental platform. However, it seems that they change their mind when they anticipate that they can have financial benefits from this.

  - Younger car-owners (up to 39 years old) and those who live in zones 1-2 (young urbanites) are more willing to share their cars via peer-to-peer car rental platforms.

- 48% of non-car owners would be happy to rent someone else's car. However, if they had a car, only 16% of them would be willing to rent out their car to someone else. It is easier for consumers to rent/use others' resources, instead of offering/sharing their own mobility resources.

- 40% of non-car-owners see themselves participating in a car sharing (car club) scheme in the future.

- Millenials (up to 39 years of age) are most open to participating in car sharing. The percentages of those who would likely participate in car sharing in the future drop significantly for the age groups over 40 years old. Those who live in zones 1-4 are more likely to participate in such schemes compared to those living further out (a trend that is most likely impacted by differences in the availability of such schemes).

In general, the idea of car-ownership has been around for almost a century now, and car manufacturers have invested incredible amounts of money to build the "dream" and the status of owning a car. Car sharing schemes have only been around for almost a decade, yet Londoners seem to have accepted this new concepts quite quickly and a significant percentage of them are willing to use them in the future, instead of purchasing their own cars.

4. Attitudes towards MaaS and car-ownership in the MaaS era

MaaS could provide a significant change to the way mobility is currently supplied. However, as the concept is not yet well known within the wider community, it is still questionable how it would be received. As such, it is important to understand peoples' attitudes, perceptions and possible concerns towards it. This section looks at individuals' attitudes towards various characteristics of MaaS (4.1) as well as their attitude towards car ownership if MaaS were available (4.2).

4.1 Attitudes towards MaaS

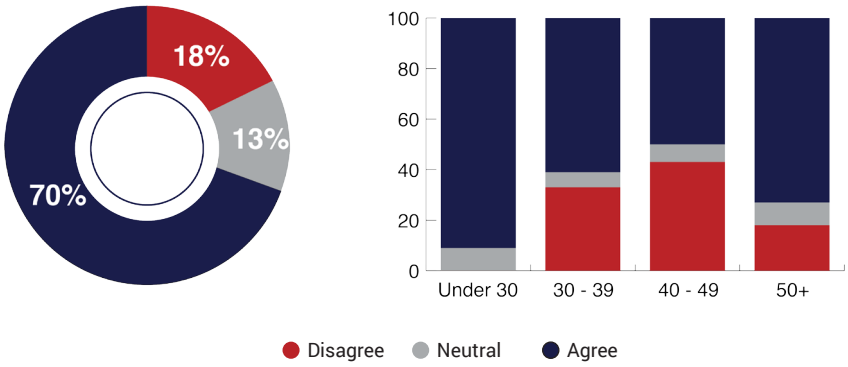
This section focuses on attitudes towards MaaS and towards trying new modes if MaaS were available. To start, elements that could help the diffusion of MaaS (especially at early stages) are examined. As with all bundled services (e.g. restaurant menus, mobile phone subscriptions), pricing the bundle of products below the sum of the same amount of products bought individually is a good strategy to get more people interested. This can be presented to users as discounts or as MaaS special offers, for example getting some free car sharing hours by signing up to the service.

70% of respondents stated that they agree with the statement that "I would be willing to subscribe to MaaS if it gave me discounts", while only 18% disagreed (Figure 4.1.1). When looking at it more closely, over 90% of under 30 year olds agree with this statement, while none of them disagree. This supports the argument above that this age group is the most price sensitive. This finding could help the diffusion of MaaS in the younger age groups. The group with the highest fraction (43%) of respondents disagreeing to this statement is the 40-49 age group. This can indicate two things: either they are not price sensitive and would be willing to subscribe to MaaS even without discounts; or even discounts wouldn't be enough to motivate them to subscribe.

Half of the respondents indicated that they agree with the statement "MaaS special offers would motivate me to subscribe to MaaS", while only 27% disagree with it (Figure 4.1.1). When breaking it down by age group, under 30 year olds have the highest percentage who agree with being motivated by special offers (63%). This follows the same logic as above, as this group is still early on in their careers (or are still students) and are more price sensitive, thus could be persuaded easily by the potential better value for their money. The other age categories have a similar split between agree-neutral-disagree.

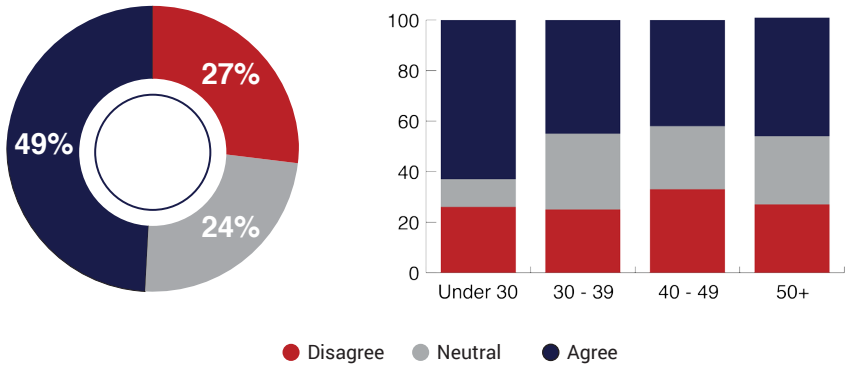
Fig. 4.1.1: Londoners' attitudes towards MaaS

"MaaS special offers would motivate me to subscribe to MaaS"



- 70% of respondents would be willing to subscribe if MaaS gave them discounts
- The age group with the largest fraction of people motivated by discounts is the under 30 group with over 90% agreeing with the statement

"I would be willing to subscribe to MaaS if it gave me discounts"



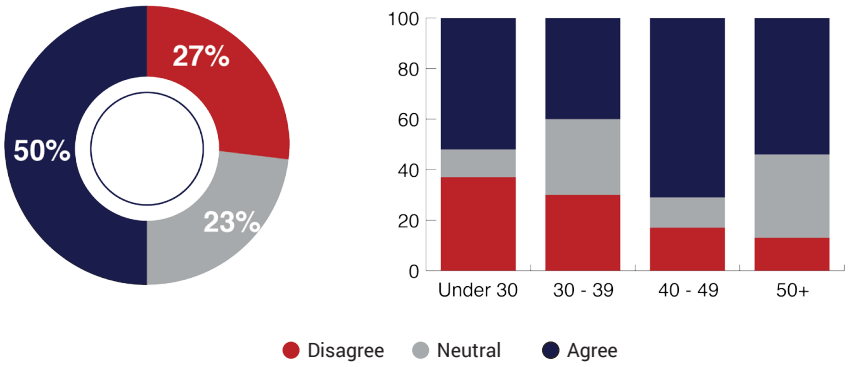
- Half of the respondents agree that special offers would motivate them to use MaaS
- The highest fraction of people who would be motivated by special offers are people under 30

While knowing what could motivate people to subscribe to MaaS is important, it is equally as valuable to know what factors discourage them from using the service. 50% of respondents stated that they would “worry about running out of their subscribed amounts of travel”, while 27% stated that they would not (Figure 4.1.2). This shows one of the key pain points of subscription services, that people are uneasy about their situation if they were to run out of their pre-paid amounts of the service. In order to mitigate this, MaaS providers should make it clear what happens in such cases. Do they go over to pay as you go? And if yes, at what costs? Breaking down this statement by age, the group where the highest percentage of people are worried about running out of their subscription, is the 40-49 age group. 70% of this group agreed with the statement, while only 17% disagreed. The highest fraction of people who disagreed with being worried about running out of their subscribed amounts are the under 30 and 30-39 age groups at 37 and 30% respectively. Interestingly though, the fraction of the under 30 group who stated that they agree with the statement is 51%, showing that this age group has strong opinions in both directions.

Another potential discouraging factor is that respondents “would feel trapped by subscribing to MaaS”. 41% of the respondents agree with this statement, while 36% disagree (Figure 4.1.2). This shows that there is a split in how the population feels about being trapped with MaaS. When breaking it by age group, similarly to before, the 40-49 age group has the highest fraction of people who agree with the statement (54%). This shows the sensitivity and uneasiness of this age group to multiple characteristics of subscription services. The over 50 age group has the lowest percentage of people who agree with this statement. Looking at the other end, the highest proportion of people disagreeing with this statement is the under 30 year olds, while the lowest is to 40-49 age group. Almost half of the under 30s disagree, indicating that they are less nervous about the commitment to MaaS plans.

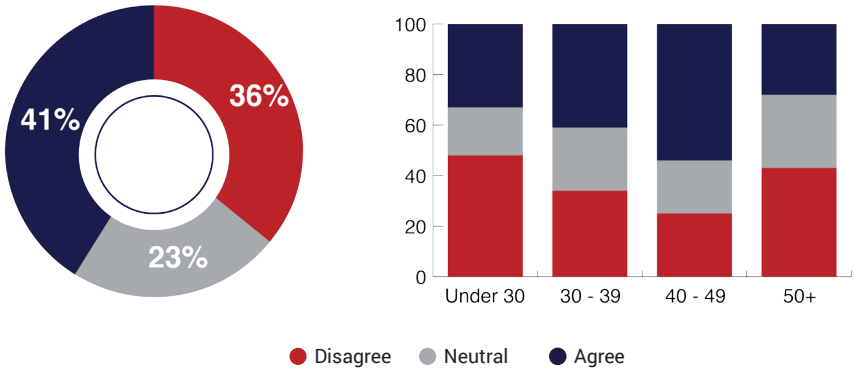
Fig. 4.1.2: Londoners' attitudes towards MaaS

"I would worry about running out of my subscribed amounts of travel"



- 50% of respondents stated that they would worry about running out of their subscribed amounts of travel
- The age group 40-49 is the most concerned about running out of subscribed amounts of travel, while the under 30 group has the highest fraction of people who are not worried

"I would feel trapped by subscribing to MaaS"

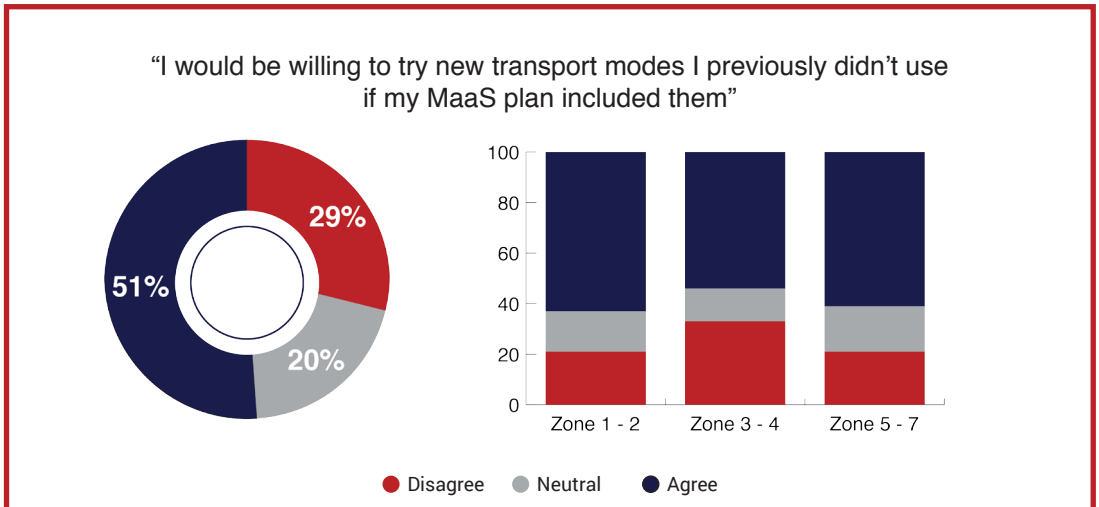


- 41% of people would feel trapped by subscribing to MaaS as they correlate this with mobile phone contracts
- The most concerned age group is 40-49 year olds, while the least is the under 30 year olds

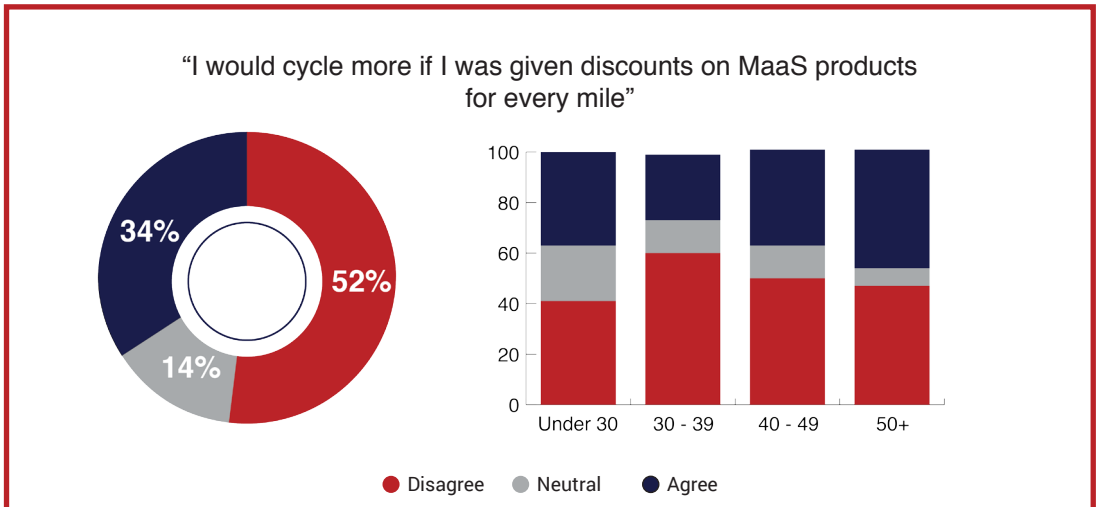
MaaS plans could be used as a travel demand management tool and could help motivate people to use more shared and sustainable modes. Half of the respondents agreed, while only 29% disagreed to the statement “I would be willing to try new transport modes they previously didn’t use if my MaaS plan included them” (Figure 4.1.3). This means that once people subscribe to a MaaS plan, they are willing to try the transport modes included in them, thus the plans can be used to promote certain modes. This is very promising considering that one of the objectives of MaaS is to shift people to use more shared modes – many of which are currently not used by masses. When looking at the respondents by residential zone, there is a slight difference between the central (1-2) and outer (5-7), and inner (3-4) zones. Out of those who live in central and outer zones over 60% agree, while 21% disagree with this statement. The same values for inner zones is 55% and 33% respectively. This shows that slightly more residents living in central and outer London zones are open to trying new transport modes with MaaS than inner London residents.

An innovative idea to motivate people to use more active modes is to give them something back for every mile they conduct with these modes. 34% of respondents agreed that they “would cycle more if they were given discounts on MaaS products for every mile” (Figure 4.1.3). Interestingly the older age group (50 and over) has the highest percentage of people who agree with this statement (47%), while the 30-39 age group has the highest percentage of people who disagree (60%).

Fig. 4.1.3: Londoners openness to use transport modes they have not used before



- Half of the respondents agree that they would be willing to try new transport modes they previously did not use if their MaaS plan included them
- No matter the zone they live, more than half of the respondents stated that they are likely to try new transport modes with MaaS



- 34% of respondents agree that they would cycle more if given discounts on MaaS products for every mile
- The highest percentage of respondents who agree to this statement are in the 50 and over age category, following by the under 30 age group

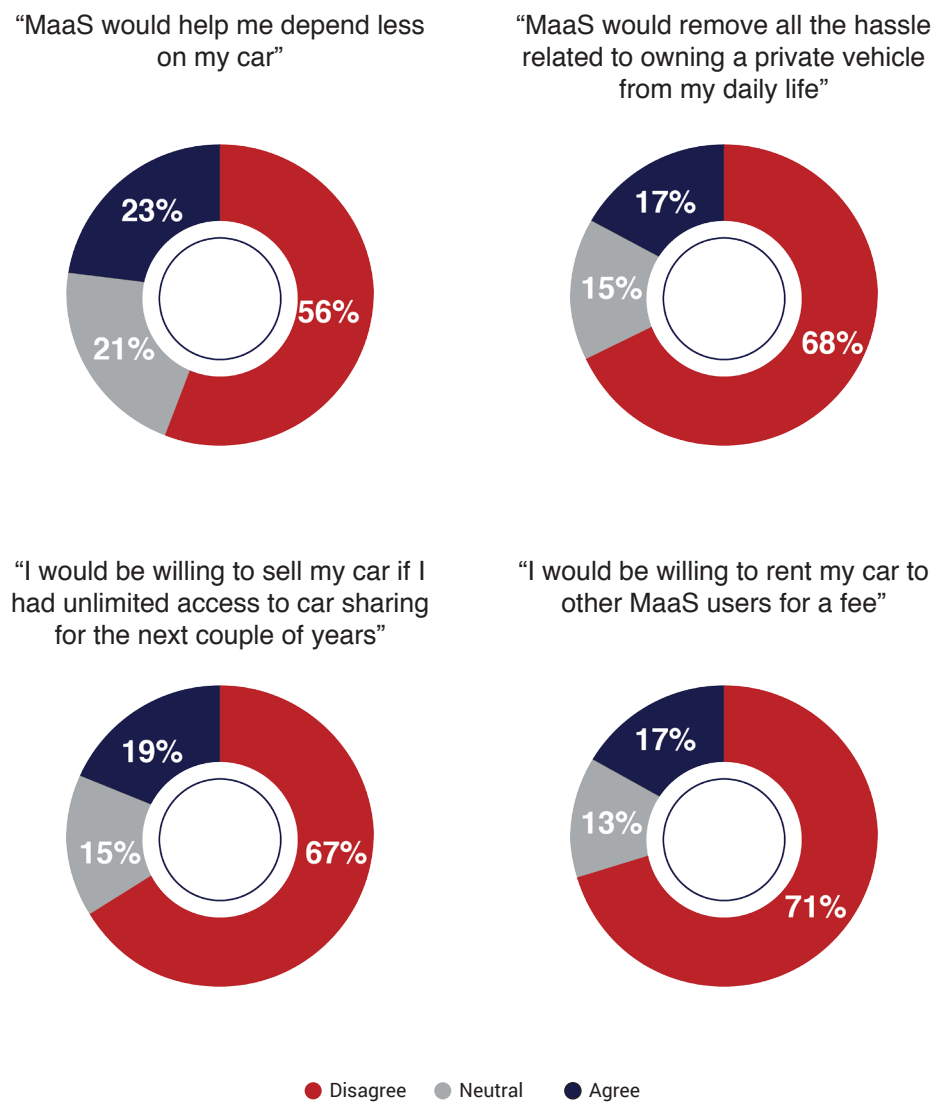
4.2 Attitudes towards car ownership with MaaS

One largely uncertain question is what will happen to car ownership if MaaS were introduced. A hope of MaaS advocates is that it will eradicate dependence on private vehicles in the mid-long term. This section looks at current car owners and non-car owners' attitudes towards cars and car purchasing if MaaS were available.

Below, car owners' attitudes towards statements related to their vehicles if MaaS were available are depicted (Figure 4.2.1). Even though 56% disagreed, 23% of respondents who own private vehicles agreed that "MaaS would help me depend less on my car". This shows that MaaS has the potential to assist in the shift away from private vehicle dependence. Further, 17% of car owning respondents agreed that "MaaS would revove all the hassle related to owning a private vehicle from my daily life".

An innovative concept to help decrease private vehicle ownership is to give car owners unlimited access to car sharing in exchange for giving up their cars. 19% of respondents agreed that "I would be willing to sell my car if I had unlimited access to car sharing for the next couple of years". Even though this may sound a bit abstract, with MaaS this could be possible service design. This also shows that these people are not emotionally connected to their own vehicles, they just need access to a vehicle. This is a subpopulation that should be specifically targeted with MaaS schemes as they are the most susceptible to shifting to the shared economy while also getting rid of their own cars. 17% of car owning respondents agreed to the statement "I would be willing to rent out my car to other MaaS users for a fee". This indicates that there is demand (albeit low for the moment) for peer to peer car sharing within the MaaS framework.

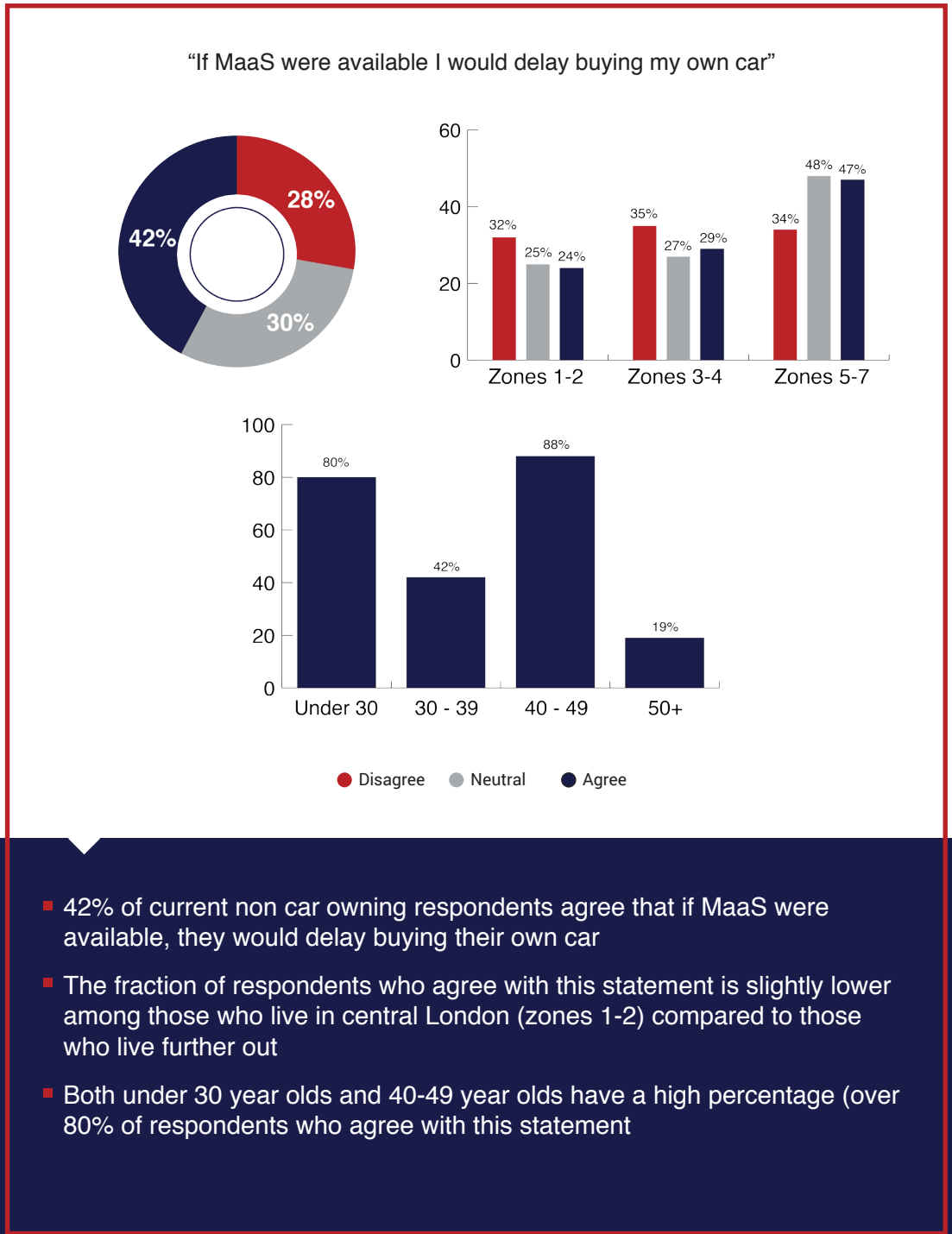
Fig. 4.2.1: Car-owners reactions towards MaaS



- 23% of respondents who own a private vehicle agree that MaaS would help them depend less on their cars
- 17% of respondents who own a car agree that MaaS would remove all the hassle related to owning a car
- 19% of car owning respondents would be willing to sell their car is they had unlimited access to car sharing for the next couple of years
- 17% of respondents would be willing to rent out their cars to other MaaS users for a fee

Looking solely at non-car-owners, 42% of respondents agreed that "If MaaS were available I would delay buying my own car" while only 28% disagreed (Figure 4.2.2). The fraction of those who agree with this statement is lower among those who live in central London compared to other zones. When looking at it by age group, the groups with the highest fraction of individuals agreeing with this statement are the under 30 and 40-49 brackets, both with over 80% of respondents agreeing. This is very important to understand, as MaaS has potential in exposing and familiarising non-car-owners with shared services, so that later they consider delaying or not purchasing vehicles at all.

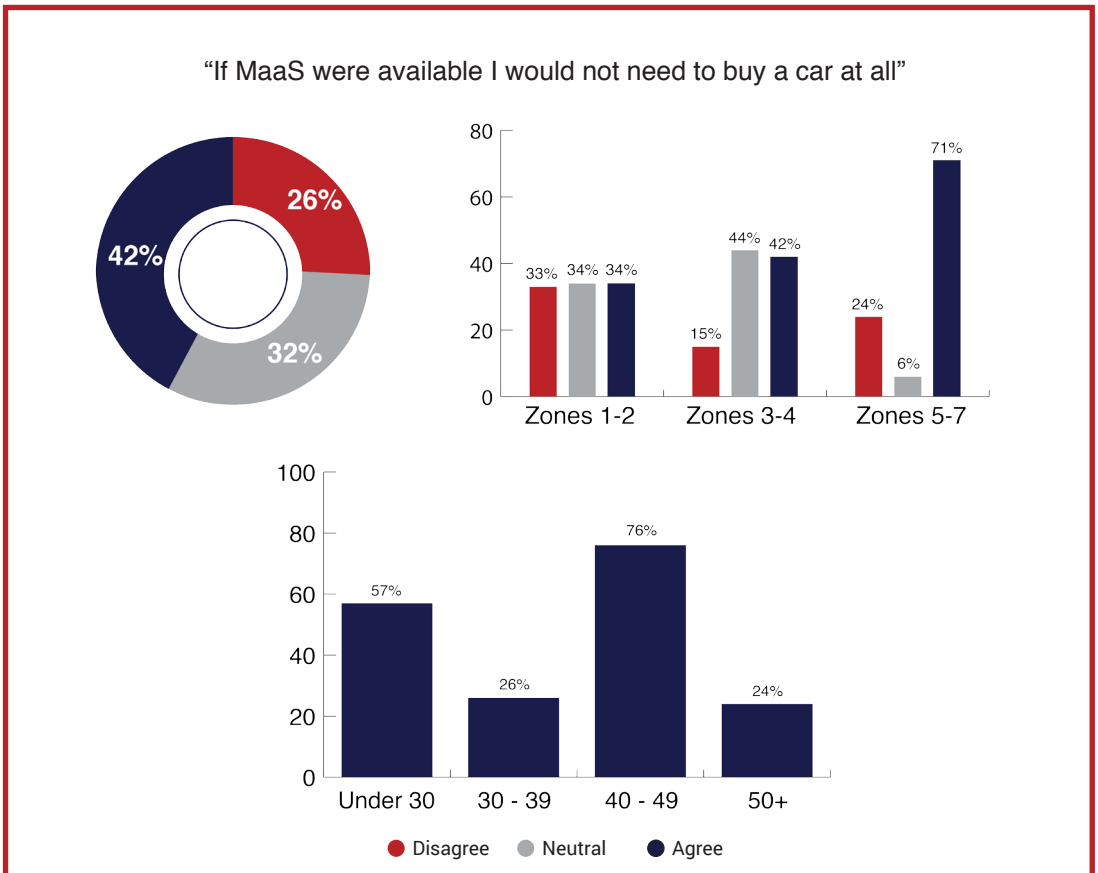
Fig. 4.2.2: MaaS and car-ownership (1)



- 42% of current non car owning respondents agree that if MaaS were available, they would delay buying their own car
- The fraction of respondents who agree with this statement is slightly lower among those who live in central London (zones 1-2) compared to those who live further out
- Both under 30 year olds and 40-49 year olds have a high percentage (over 80% of respondents who agree with this statement

Continuing to look at non-car-owners, 42% of respondents agreed and 26% disagreed with the statement "If MaaS were available I would not need to buy a car at all" (Figure 4.2.3). These results are very much in line with those for the previous statement, with only minor differences. This, alongside the numbers above for delaying car purchase, are very positive and show the potential impact MaaS can have on future car purchasing behaviour. One of the important elements of MaaS is the effect it can have in the mid to long term, as it could shift user behaviour with regards to long-term decisions. When breaking the responses down by residential zone, there are significant differences between central, inner and outer London. Out of those living in central London, there is an even split between those agreeing, feeling neutral and disagreeing with this statement. When moving further, out of those in zones 3-4, only 15% disagreed with this statement, while 42% agreed. Looking at those living in outer London, the figures shift even further, with 71% of respondents agreeing that they would delay buying a car if MaaS were available. This shows quite an interesting trend, that the further out we go, the higher the percentage of people who would delay buying their own cars. Looking at it by age group, the results resonate with those for the previous statement in that the under 30 and 40-49 age groups have the highest fractions of people agreeing, while the other two age groups (30-39 and 50+) only have about a fourth of the people agreeing to the statement.

Fig. 4.2.3: MaaS and car-ownership (2)



- 42% of respondents who currently do not own a car agree that if MaaS were available they would not need to buy a car at all
- This fraction increases to 71% if we look only at those living in outer London zones (5-7)

Highlights

- 70% of all respondents would be motivated to subscribe if MaaS gave them discounts. This percentage increases to over 90% for the most price sensitive under 30 year olds.

- 50% of respondents stated that they would worry about running out of their subscribed amount, while 41% would feel trapped by subscribing to MaaS. The 40-49 year old age group has the highest fraction of people who feel this way about both these statements indicating that they feel uneasy about multiple characteristics of subscription services.

- MaaS could be used to introduce people to public and shared transport modes, as half of the respondents agreed that they would try modes they previously didn't use if their MaaS plan included them.

- Giving individuals discounts for using active modes through MaaS schemes can be a possible way to encourage usage of these modes. 34% of respondents agreed that they would cycle more if they were given discounts on MaaS products for every mile.

- MaaS has the potential to impact current car owners' car usage and ownership behaviour. 23% of car owners agree that MaaS would help them depend on their cars less, while a fifth of them would even be willing to sell their cars for unlimited access to car sharing for the next couple of years.

- Almost half of respondents who currently don't own a car would consider delaying purchasing a vehicle or not buying one at all if MaaS were available.

Overall, even though there is still much to learn about MaaS, there are some promising insights to take away from this section. Discounts could motivate individuals, especially young people, to join MaaS and even use active modes more. MaaS plans can help balance the modal split, by introducing people to modes they previously didn't use. Finally, MaaS could support the shift away from the private vehicle ownership by helping car owners depend less on their private vehicles and delay or diminish the need for non-car-owners to purchase these.

“This chapter has intentionally been removed.
For more information, please contact the MaaSLab”

6. MaaS evaluation and scenarios for the autonomous vehicle era

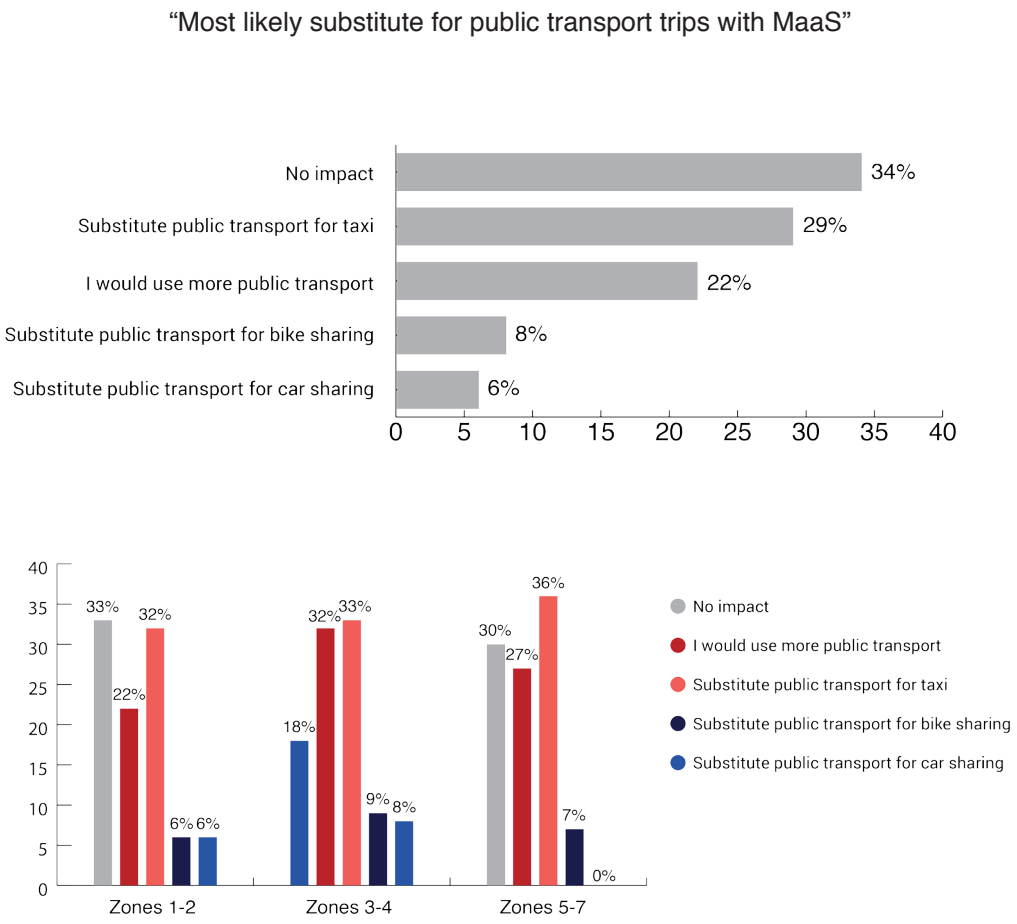
This section provides insights into the overall impact MaaS could have on the city's transportation system both from the transport operators' and travellers' perspective. First survey results on the potential effect MaaS could have on mode switching are presented. This is followed by a critical assessment on the impact MaaS and the modal shifts could have on public transport, the economy, health, the environment and users.

6.1 MaaS impact on mode switching

Understanding what impact MaaS could have on mode switching is crucial for transport operators to prepare for potential under or overprovision of certain modes. Survey participants were segmented into regular public transport users and regular car users, and questions regarding potential mode switching from these modes were specifically targeted at each segment. They were asked to indicate what their most likely substitute would be if MaaS were available, for public transport and car respectively.

Out of those respondents who are currently regular public transport users, 34% stated that if MaaS were available, it would most likely have no impact on their public transport usage (Figure 6.1.1). 29% would most likely substitute part of their public transport usage with taxi, while 22% would most likely use more public transport. 8% stated that MaaS would cause them substitute part of their public transport use with bike sharing, which shows that some public transport use could be replaced with active modes. Breaking this down by residential zone, there seems to be significant differences depending on where the individual lives. When looking at Central London zones (1-2), the most frequently chosen impact is the 'no impact' option, that is, that their public transport usage would not change. Whereas for inner (3-4) and outer (5-7) London zones, substituting public transport with taxis the most common first choice, although for the inner zones, increasing public transport is in close second place. Increasing public transport usage takes a significant percentage in all three London areas with values between 22-33%. Shared modes take the highest percentage among those living in zones 3-4, who may commute regularly to Central London and would enjoy using bike sharing for example.

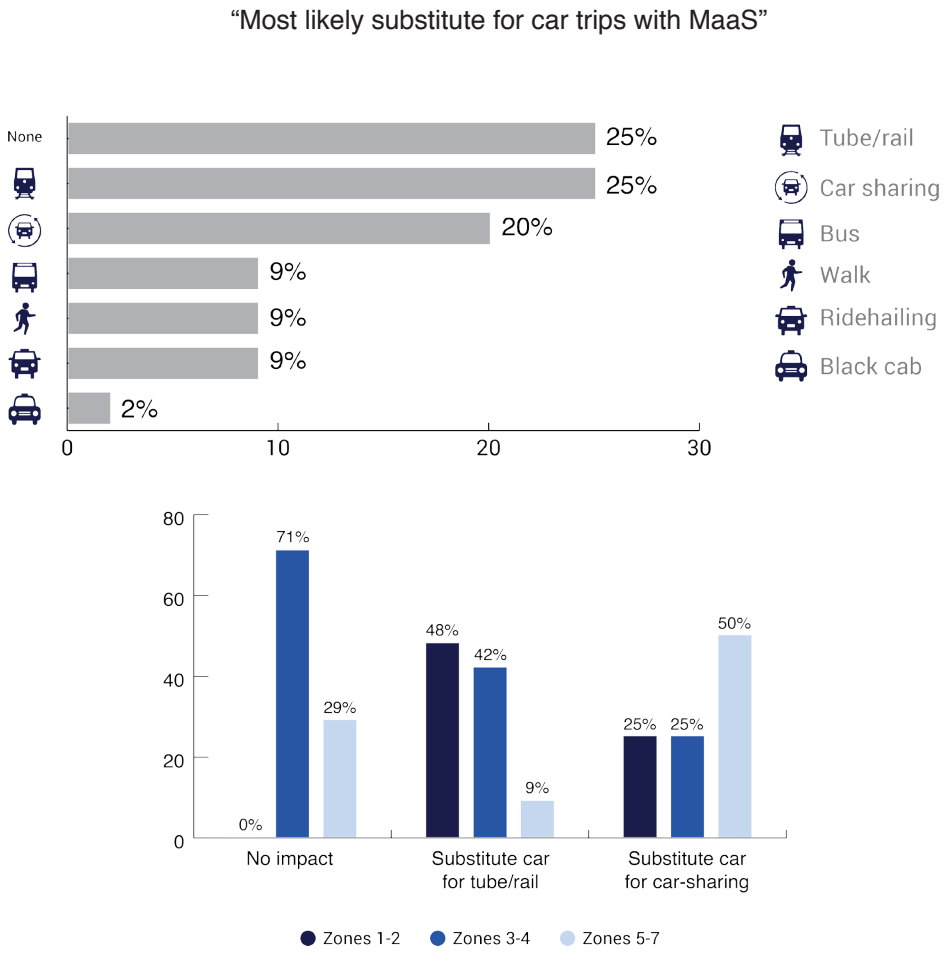
Fig. 6.1.1: Most likely substitute for public transport trips if MaaS were available



- 34% of respondents stated that MaaS would have no effect on their public transport usage, while 29% stated that they would substitute public transport for taxi and 22% would increase their public transport usage
- There are significant differences in the impact of MaaS on public transport depending on residential zone

Turning to regular car users, a quarter of the respondents stated that they would most likely substitute part of their car trips with tube/rail, while another quarter said they would most likely not substitute car with anything (Figure 6.1.2). A fifth of the respondents would substitute their private car trips with car sharing if MaaS were available, which again points at the subpopulation who aren't attached to their own vehicles, just need access to one. Looking at it by residential zone, out of those who stated that they would most likely not substitute private car trips with anything, none of them live in central London, while 72% live in inner London zones. This means, that central London residents are most likely to give up their private cars for other modes of transport if MaaS were available, while inner London residents would be the least likely. Looking at those who stated that they would most likely substitute part of their private vehicle trips with tube/rail, under 10% live in outer London zones. The split for those who chose car sharing as their primary substitute for private vehicles, half of them live in zones 5-7.

Fig. 6.1.2: Most likely substitute for car trips if MaaS were available



- 25% of individuals stated that tube/rail would be the most likely substitute for car trips if MaaS were available
- Another 25% stated that they would not substitute any of their private car trips if MaaS were available
- People living in central London (zones 1-2) are most likely to give up their private cars for other modes of transport if MaaS were available

6.2 Wider impact assessment of MaaS for London

The mode shifts described in the previous subsection and other characteristics of MaaS will most likely have an impact on several sectors. The following tables (Tables 2 to 6) provide an assessment of the impacts MaaS could have on several sectors, such as public transport, the economy, data, the environment and health as well as society (Londoners). For each topic, the impacts and their scale are assessed. The assessment provided below is a thought experiment[27] based on the analyses presented above.

Table 2: Impact assessment of MaaS on Public Transport

Topic	Impact	Scale of Impact
Passenger demand	- The demand for public transport services is likely to rise as a great proportion of car users would increase their usage of public transport (Fig. 5.1.3). - Nonetheless, the extent to which the demand could rise depends largely on the chosen MaaS plans (Fig. 5.1.2) and the degree of switching away from public transport (29% of the regular public transport users would substitute part of the usage with taxi).	Minor positive
Capacity optimisation	- MaaS will significantly improve the network efficiency. Especially in peak hours, the excessive traffic can be redirected to under-utilised routes or other transport modes. -MaaS can optimise supply and demand.	Positive
Flow at stations	- The single ticketing and payment feature offered by MaaS could speed up the passenger flows in ticketing halls. - Passengers will be able to receive or check real-time information by subscribing to relevant MaaS services, which could reduce the volume of enquiry demand at stations.	Positive
Intermodal connectivity	- Internally, tube, rail and bus services will be more tightly connected from passengers' point of view as they can access the information of these services all in one place. - Externally, public transport will be connected with those private modes that are also covered in MaaS. In this way, seamless mobility can be achieved. From the perspective of economics, public transport could act as a complement to private modes and their demands would therefore reinforce each other.	Positive
Revenue	- The potential increase in demand will generate additional revenue to the public transport operator, which could be reinvested to improve service quality. - MaaS could also minimise the loss of the transport authority from some unter-utilised routes (especially bus routes).	Minor positive
Number of private vehicles on the road	- MaaS could remove a significant number of private vehicles off London roads, as only 25% of the car-using participants stated that they would not switch modes with MaaS. - Congestion could be alleviated as a result of this. - However, measures should be taken to avoid any increase in the number of taxi and ridehailing vehicles.	Minor positive

[27] A thought experiment is a device with which one performs an intentional, structured process of intellectual deliberation in order to speculate, within a specifiable problem domain, about potential consequents (or antecedents) for a designated antecedent (or consequent) (Yeates, 2004)..

Table 3: Impact assessment of MaaS on London's economy

Topic	Impact	Scale of Impact
New business opportunities	- The provider/operator of the MaaS system(s) could be the city's public transport authority or a private enterprise. In the latter case, the MaaS operator(s) can pay taxes, which will generate income for the government. - The operation of MaaS has high requirement on ICT infrastructures such as high speed internet (3G and 4G) and widespread geographical internet coverage. As such, MaaS could expand the market for ICT companies as well. - MaaS could also unravel business opportunities for insurance companies providing them the option to expand their portfolio and increase their revenue. Insurance providers may be called upon for example when a transport mode proposed by MaaS is unable to respond to the request in the promised time window etc. - MaaS could also provide new business opportunities to data provider companies as the requirements for high quality, real time data processing are high.	Positive
Revenue to transport operators	- Transport operators via the MaaS operator(s) have the opportunity to access a wider market and increase their market share. - Transport operators also have the opportunity to grow their revenue from previously 'unreachable' customer segments. The MaaS system can optimise demand and supply by knowing in real time the demand and the capacity of transport operators. This would be valuable in peak hours when some of the transport operators run on full capacity and MaaS could redirect their demand to other transport operators. - There will however be short-term costs to transport operators as they would need to install sensors on their fleet and ticketing systems that accept smartphone reading in order to supply the required data to MaaS. - Additionally, the MaaS system creates the potential for direct competition between engaged operators. The outcome may be reflected on a decrease in prices and in turn the revenue to operators.	Positive
Small to medium sized enterprises (SMEs)	- MaaS customers can be individual travellers or companies. In the latter case, the service is able to offer customised packages and match companies' special requirements. SMEs can take this opportunity to cut down their employees' travel costs and avoid the fixed costs of purchasing vehicles. - MaaS can also serve the freight transport sector and bring down the costs accordingly.	Positive

Table 4: Impact of MaaS on data availability for planning

Topic	Impact	Scale of Impact
Data quality	- A well-operated MaaS system can gather abundant and highly-reliable travel behaviour data as every piece of the travel information (origin-destination, interchanging points, trip duration and cost etc.) will be captured and stored automatically when using the MaaS services. - The authority can make use of the available data to design more effective policies for many purposes. - Customers' data protection protocols (anonymisation and aggregation) should be applied when data is transferred to the collaborators/suppliers of the MaaS operator(s).	Positive

Table 5: Impact assessment of MaaS on the environment

Topic	Impact	Scale of Impact
Air quality	- MaaS has the potential to significantly decrease private vehicle use due to behavioural changes of car owners (only 25% of car users stated they would not consider alternative options if MaaS were available) and non-car-owners (42% stated they would not buy a car in the future). These shifts away from private vehicles could alleviate congestion which would cause meaningful improvements air quality. -However, the decreases in congestion and associated air quality improvements depend on what modes car users are shifting to. 25% of car users stated that they would shift to tube/rail and 9% to walk which would have positive effects. 25% would shift to car sharing, which depends on the type of car sharing; if it is electric car sharing this would be positive as well. However, 9% stated that they would use the bus more and 9% would use P2P taxi. This could lead to an increase in demand for buses and taxis which could create pollution problems - Nevertheless, MaaS, in conjunction with the incoming Ultra Low Emission Zone (ULEZ) scheme, could make sure the 'polluters' pay, not the others. ULEZ will charge all car users; however, by introducing MaaS, those who are willing to contribute to air pollution reduction are offered an equally convenient alternative to their cars and can therefore avoid the charge. In comparison, those who will still drive while MaaS is available will have no excuse to avoid the charge.	Minor positive
Noise	- Fewer cars and more active modes are expected to be on streets meaning that the noise level could go down. - There could however be additional noises arisen from the interchanges across transport services.	Minor positive
Climate change	- Similar to air quality improvement, the savings of carbon emission also depend on the type of mode switching. - More importantly, the emission reduction from a city's urban transport sector cannot have a considerable wider impact on climate change.	Neutral

Table 5 continued

[28] Inrix, Available at: http://inrix.com/press-releases/traffic-congestion-to-cost-the-uk-economy-more-than-300-billion-over-the-next-16-years/

Landscape and urban realm	- As private car ownership is expected to drop, some car parks could become redundant and could be rebuilt to serve other purposes. Much of on street parking will also be freed, allowing for more pedestrian and retail spaces and an overall better living environment for residents, - However, the volume of street parking for shared-vehicles is likely to grow given the increasing demand for car sharing, an important substitute to private car (Fig. 6.1.2).	Neutral

Table 6: Impact assessment of MaaS on health

Topic	Impact	Scale of Impact
Air pollution	- Given the 'Minor positive' effect on air pollution reduction, we would expect the further impact on health is even more limited as 'neutral'.	Neutral
Noise	- Similar to the above.	Neutral
Physical activity	- The level of physical activity is expected to be higher than the current status. It is shown that some car users would switch directly to bike sharing and walk when MaaS is available (Fig. 5.1.3, Fig. 6.1.2). Additionally, the more frequent interchanges across modes will inevitably incur extra walking to travellers. -However, since the main alternatives to car as identified in the analysis are not those active modes, the effect on physical activity level may not be too significant.	Minor positive

Table 7: Impact assessment of MaaS on Londoners

Topic	Impact	Scale of Impact
Travel cost saving	- MaaS will not change the charging scheme of transport operators; however, MaaS users can benefit from an overall cost reduction and better value for money by subscribing to bundled mobility packages. - Besides, the direct competition among transport operators may lead to a drop in their service prices, which would further save travellers' costs. -Car owners will have a good alternative to owning a car (23% of respondents stated that MaaS would help them depend less on their cars), many may opt to sell their cars and use MaaS instead. As MaaS plans would definitely be cheaper than the overall cost of owning a car, these people would incur significant cost savings.	Positive
Travel time saving	- Significant reduction in journey time is highly expected. MaaS users can save time with the single ticketing & payment service to speed up interchanges, and avoid congestions on roads and on public transport networks by having real-time, intermodal information.	Positive
Travel experience improvement	- The hassle-free interchanges, the better control over disruptions and the personalised mobility packages will undoubtedly increase the convenience and comfort levels and hence make travellers more satisfied with their journeys.	Positive

Table 7 continued

Travel experience improvement	- Personalised real time travel information will also lead to better user experience.	Positive
Equalities		
Age (younger <30)	- The younger generation is very likely to benefit from MaaS. The percentages are high in saying they would delay buying a car (80%) or would not buy a car at all (57%) if they can use MaaS (Fig. 4.2.2, Fig. 4.2.3).	Positive
Age (older 50+)	- MaaS is found to affect the eldest group the least as the corresponding percentages to "would delay buying a car" (19%) or "would not buy a car at all" (24%) are the lowest among all age groups. -However, not everyone in the age group will have access to or be comfortable using smartphones to aid in travel purposes. These people will not be able to use MaaS services. This will only be a problem in the mid-term as those growing up in the smartphone era will carry this technological knowledge on to when they become older.	Minor positive
Disabled travellers	- The seamless mobility will in general enhance the accessibilities of disabled travellers, due to the fact that MaaS can assign special vehicles to this population group. - However, public transport is expected to be more crowded and this may increase the travel difficulties for disabled passengers.	Minor positive
Downtown residents	- MaaS seems to be more welcomed by the residents in central London (zone 1 and 2) as these people are more willing to substitute their cars with alternative options (Fig. 6.1.2).	Positive
Suburban residents	- On the contrary, residents in outer areas are less likely to give up cars. In particular, 71% of the car users from zones 3 and 4 stated that they would continue using their cars even when MaaS becomes available.	Minor positive

6.3 MaaS in the autonomous vehicle era

Even though MaaS developments will most likely reach maturity well before driverless vehicles are ready for mass adoption, it is worth looking ahead to the autonomous vehicle era. Public transport looks like a frontrunner. Driverless rail and underground lines have been operating for quite some time, and a few autonomous bus fleets are already in operation (e.g. Arma bus in Las Vegas and Intellibus in Western Australia). Meanwhile, shared mobility sector is also expected to change. With a wider application of autonomous vehicles in the future, car sharing, ridesharing and ridehailing services could be delivered by driverless vehicles as well.

When the time comes, MaaS systems and autonomous vehicles will exist in symbiosis. First of all, as in the non-autonomous case, MaaS users will only need one account to access the autonomous vehicle services supplied by different public transport and shared mobility companies. With autonomous vehicles, travel time can be used for other useful activities such as reading, sleeping or working etc. Hence, minimising travel time will not always be the best option and the MaaS system will help utilise this by capturing travellers' preferences on whether they want to arrive at destination in the shortest amount of time or would rather be able to use it productively. Furthermore, the real-

time information offered by MaaS will be more efficiently used. In case of a disruption, instead of informing a vehicle driver and letting the driver be in the hassle of re-routing, an autonomous vehicle can process the information faster and generate the best decision. At urban level, this could allow for better system optimisation and decongesting the city.

To take one step back, MaaS could also aid in achieving a future situation where people prefer public transport and shared mobility services in the autonomous vehicle era. An opposite situation that could possibly occur is the flourishing of privately owned autonomous vehicles given that all the current barriers to driving such as parking, driving license and opportunity cost of the time spent driving will vanish. In fact, the latter situation is more likely to occur if travel behaviour patterns persist as they are now (i.e. private car is still an important travel option). As a result, more severe congestion and air pollution would be expected in urban areas. By having such a risk, it is imperative to make MaaS function as early as possible. Results in the previous sections have shown that an implementation of MaaS could effectively reduce people's dependence upon owning and using private cars. Hence, MaaS actually brings an opportunity to change travel behaviour prior to the mass adoption of autonomous vehicles. If more people shift away from private cars nowadays via MaaS, it will more likely lead to a boom in public transport and shared mobility sectors when the era comes, rather than a swarm of privately owned autonomous vehicle.

Highlights

- 34% of the regular public transport users stated that their usage of public transport would not change if MaaS were available while 22% of them would use more public transport. Meanwhile, 29% would most likely substitute part of their public transport usage with taxi.

- 25% of the regular car users stated that their car usage would not be affect by MaaS and another 25% said they would most likely substitute part of their car trips with tube/rail. Additionally, 20% of these respondents would substitute their car trips with car sharing if MaaS were available.

- Car users living in zone 1 and zone 2 are most likely to give up their car trips and switch to other alternatives when MaaS becomes available.

- MaaS is expected to cut down Londoners' travel cost and travel time, improve their travel experience as well as reduce their dependence on private cars.

- Public transport would benefit significantly from joining MaaS in terms of better capacity optimisation and better intermodal connectivity. It is also expected the demand for public transport will rise and so will the revenue to the operator.

- MaaS can open up new business opportunities for the operator of MaaS, data provider companies, and ICT and insurance industries etc.

- MaaS, in conjunction with the Ultra Low Emission Zone (ULEZ) scheme, could make sure the 'polluters' pay, not the others. ULEZ will charge all car users; however, by introducing MaaS, those who are willing to contribute to air pollution reduction are offered an equally convenient alternative to their cars and can therefore avoid the charge. In comparison, those who will still drive while MaaS is available will have no excuse to avoid the charge.

- When the era of autonomous vehicle comes, MaaS systems and autonomous vehicles will exist in symbiosis. MaaS users will only need one account to access the autonomous vehicle services supplied by different public transport and shared mobility companies. MaaS will also help utilise the time freed from driving by capturing travellers' preferences on whether they want to arrive at destination in the shortest amount of time or would rather be able to use the time productively. In addition, the real-time information offered by MaaS will be more efficiently processed by autonomous vehicles.

- MaaS could also aid in achieving a future situation where people prefer public transport and shared mobility services in the autonomous vehicle era. MaaS actually brings an opportunity to change travel behaviour prior to the mass adoption of autonomous vehicles. If more people shift away from private cars nowadays via MaaS, it will more likely lead to a boom in public transport and shared mobility sectors when the era comes, rather than a swarm of privately owned autonomous vehicle.

APPENDIX A

	Total Sample N = 343 obs. (used for analysis in Sections 2, 3)	**Sample for MaaS analysis** N = 119obs. (used for analysis in Sections 4,5,6)	**London Statistics** N = 14,726 obs. (source: LTDS 2014, 18+only)
Gender			
Male	35%	45%	47%
Female	65%	55%	53%
Age			
Up to 29	25%	23%	21%
30 – 39 years old	44%	44%	22%
40 – 49 years old	17%	20%	18%
Over 50 years old	14%	13%	39%
Residential zone[29]			
zones 1-2	38%	44%	26%
zones 3-4	35%	38%	45%
zones 5-7	27%	18%	29%
Marital Status[30]			
Single	45%	36%	Not available
Married	51%	61%	Not available
Divorced/Widowed	4%	3%	Not available
Educational level[31]			
Basic (GCSE or equivalent, high school diploma)	17%	13%	Not available
Bachelor's degree	48%	54%	Not available
Masters degree	26%	27%	Not available
Doctoral degree	9%	6%	Not available
Ethnicity			
White British	61%	66%	52%
Irish	2%	2%	2%
Other White	18%	18%	15%
Mixed or multiple ethnic groups	3%	3%	2%
Black or Black British	3%	2%	10%
Asian or Asian British	10%	6%	17%
Other ethnic group	3%	2%	2%

[29] The residential zone information for London comes from LTDS 2012, after which the information is no longer available.

[30] Marital status is not captured by LTDS.

[31] Educational level is not captured by LTDS.

Household Income			
Up to £19,999 (1,2,3,4)	10%	9%	20%
£20,000-£35,000 (5,6)	14%	10%	12%
£35,000-£50,000 (7)	14%	13%	9%
£50,000-£75,000 (8)	20%	21%	10%
£75,000-£99,000 (9)	13%	15%	5%
£100,000 or more	18%	20%	6%
Prefer not to say	11%	11%	38%
Kids in the Household			
No kids	67%	77%	84%
Have kids	33%	23%	16%
Driving license			
Has license	75%	85%	67%
Does not have license	25%	15%	33%
Have household vehicle			
Household has vehicle	53%	55%	66%
Household does not have vehicle	47%	45%	34%

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