Evaluating Mobility as a Service for sustainable travel among young adults

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Abstract

Young adults delay obtaining their driver's licence, make fewer trips and are more open to using different transport modes. The continuation of this trend as young adults transition from university education into the workforce is less certain. This thesis explores the potential of Mobility as a Service (MaaS) to shift university graduates away from cars and towards public transport and shared mobility services, using the metropolitan city of Birmingham, UK as a case study. MaaS is an app-based scheduling, booking and payment platform for multiple transport modes on a per trip or subscription basis.

First, questionnaire survey data was analysed using Ajzen's Theory of Planned Behaviour to understand multimodal travel behaviour. Second, a discrete choice experiment was used to test the attractiveness of a MaaS subscription relative to conventional transport modes. Third, semi-structured interviews explored the underlying factors influencing graduates' travel choices as they transition from university education to the workforce using Michie's Capability, Opportunity and Motivation Behaviour model.

The results of the quantitative studies found cost, time, accessibility, and the opinions and behaviour of significant others influence participants' choice of transport mode. The interviews revealed how students' negative experiences of using public transport had motivated them to learn to drive, and the transition into the workforce provided the financial means to buy a car. Information and communication technologies were found to play a role in influencing young adults' travel choices as shown by the reliance on smartphone travel apps. The uptake of MaaS in the current market is optimistic given the relative appeal of its cost, time, and flexibility. The adoption of MaaS among young adults depends on institutional incentives, location, and ease of use. Overall, the flexible multimodal characteristics of MaaS needs strengthening if it is to reduce car-based commuting among new graduate employees.

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Table of Contents

List of Figures

List of Tables

List of Acronyms and Abbreviations

AFT	Autonomous flying taxi
ANA	Attribute non-attendance
AT	Autonomous taxi
ATIS	Advanced Traveller Information Systems
AV	Autonomous vehicle
BCW	Behaviour Change Wheel
BCU	Birmingham City University
CAZ	Clean Air Zone
COM-B	Capability, Opportunity, and Motivation Behaviour model
DCE	Discrete choice experiment
DfT	Department for Transport
EV	Electric vehicle
FA	Factor analysis
GHG	Greenhouse gas
HESA	Higher Education Statistics Agency
ICT	Information and communication technology
MaaS	Mobility as a Service
MOA	Motivation, Opportunity, and Ability model
NOA	Needs, Opportunities and Abilities model
ONS	Office for National Statistics
PBC	Perceived behavioural control
PCA	Principal components analysis
ROA	Requirements, Opportunities and Abilities model
TDF	Theoretical Domains Framework
TDM	Travel Demand Management
TNC	Transportation Network Companies
TPB	Theory of Planned Behaviour
TRA	Theory of Reasoned Action
TfWM	Transport for West Midlands
UAM	Urban air mobility
UK	United Kingdom
UoB	University of Birmingham
WTP	Willingness to pay

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Chapter 1 Introduction

1.1 Background motivation

The transport sector contributes significantly to global greenhouse gas (GHG) emissions and has faced challenges in achieving sustainability goals. The United Kingdom (UK) serves as an example. In 2019, the sector contributed 30% of end user GHG emissions, which is the highest percentage when compared to other sectors: business (25%), residential (21%) and agriculture (10%) (BEIS, 2021). Historically, the transport sector has been the second most emitting sector, after the energy sector. Whereas other sectors have rapidly reduced emissions, for instance, with the growth of renewables in the energy sector and efficiency improvements in technology, the transport sector has lagged. Since 2016, it is the highest emitting sector (BEIS, 2021). Within the transport sector – road, air and rail – road transport has the greatest impact on emissions (Kazançoğlu et al., 2021), specifically passenger petrol and diesel vehicles (BEIS, 2021). Motor vehicle traffic volumes have generally increased between 1990 and 2019, other than a fall recorded between 2007 and 2010 following the recession (BEIS, 2021). The Department for Transport (DfT) UK (2020) reports that most of the trips made in 2019 were by private transport, and most trips per person were for leisure purposes, followed by commuting and business trips. Most commuting trips were made by private car (DfT, 2020).

As a growing population travels to work, education, and leisure activities, it is predicted that the need for urban and sub-urban transport will continue to rise, resulting in a further increase in emissions, noise, congestion, and overloaded infrastructure (Karlsson et al., 2019). Curbing mobility would reduce the impact of transport on the environment. However, many parties are understandably opposed to this given its strong historic link to economic growth (Batty et al., 2015). With projected growth in travel (Ciuffini et al., 2021), several governments and local authorities have begun encouraging a modal shift away from internal combustion engine cars to more sustainable forms of transport. Sustainable transportation methods satisfy current transport and mobility needs without compromising the ability of future generations to meet their own (Black, 1997). This means that a sustainable transportation system is one that allows the basic access needs of individuals and societies to be met safely, is affordable and supports a vibrant economy, and limits emissions and waste by limiting consumption of renewable resources to the sustainable yield level (Litman, 2007). Sustainable transport has become a headline goal for transport planning and policymaking around the world (Sorensen and Gudmundsson, 2010).

There are different definitions of what sustainable transport means. However, it commonly includes efforts to improve the environmental performance of transport systems and to promote a modal shift from private vehicles to public transport and shared mobility services, including micromobility (Sorensen and Gudmundsson, 2010, Batty et al., 2015). To meet increasing fuel efficiency requirements while reducing the environmental impact of transport, various researchers have explored alternative fuels for vehicles (Zhao et al., 2020). Clean and sustainable fuels, such as biofuels converted from biomass, compressed natural gas, hydrogen and electricity have attracted attention (Zhao et al., 2020). Over the past several years, governmental support for the electric vehicle (EV) has increased in many countries (Rietmann and Lieven, 2019). The EV has been extensively promoted as an important instrument to decarbonise transport (Kester et al., 2018). In 2020, the highest shares of electric vehicles in national new car registrations were found in Norway (75%), Iceland (46%), Sweden (33%) and the Netherlands (28%) (EEA, 2021). However, consumer sales of EVs are still rather low in most countries (Rietmann and Lieven, 2019). Therefore, despite improvements in fuel efficiencies, the levels of GHG emissions from the transport sector have not changed considerably between 1990 and 2019 (BEIS, 2021, Paulsson, 2018). Hickman et al. (2010) explains this by pointing out that any gains made in terms of greater vehicle fuel efficiencies are likely to be offset by increased kilometres travelled unless there is complementary behavioural change i.e., reduced travel distances and modal shift.

For the environmental benefits of sustainable transport to be felt, people need to substitute travelling by car with other transport modes (Zhao et al., 2020, Sorensen and Gudmundsson, 2010). Public transport plays an important role in lowering the transport sector's GHG emissions as it has the capacity to move large groups of commuters, making it more sustainable compared to other modes of motorised transport (Paulsson, 2018). However, peoples' travel behaviour and travel choices influence the sustainability of such transport systems (Schneider, 2013).

Historically, encouraging private car users to use public transport has been difficult to achieve (Batty et al., 2015). Changing travel behaviours is extremely difficult because they are fundamental to people's lifestyles and can be costly in terms of money, time, and effort (Sussman et al., 2020). People's travel needs are complex, and choices are not made based on the characteristics of individual trips, but on travel needs over weeks and months. Thus, researchers in transport-related fields have applied behavioural theories to understand and predict transport behaviours. Developing a greater understanding of what makes public transport attractive – or not – is an important part of improving the quality of public transport and producing successful policies to encourage modal shift. This understanding is made even more challenging as the urban transport sector undergoes significant changes with the application of information and communication technologies (ICT). Researchers have limited information and data about how these services affect transport decisions and travel patterns (Clewlow and Mishra, 2017, Chatterjee et al., 2018).

1.1.1 Use of ICT for sustainable transport

The use of ICT can be perceived as a tool that makes public transport or non-motorised transport options more usable and more user-friendly (Bąk and Borkowski, 2019). According to Mostofi (2021) the two most popular ICT services in urban mobility behaviours are Advanced Traveller Information Systems (ATIS) and Transportation Network Companies (TNCs). ATIS are navigation services such as Google Maps, which provide real-time information about the available transport modes in an area with online mapping and route optimisation provided via the internet and mobile applications. ATIS maps have the potential to reinforce sustainable mobility behaviours among travellers as they reduce the uncertainty of travelling by public transport and shared vehicles. This is done by providing reliable information about the optimised time plan and routes for public transport users (Mostofi, 2021). TNCs form part of the sharing-economy paradigm – also known as ridesourcing platforms – where prearranged rides, such as the services of Uber, Lyft, car rentals for a fee, bike sharing or e-scooter sharing companies as well as car sharing are offered via the internet and mobile applications. TNCs have the potential to reduce the reliance on private cars and increase the occupancy rate of a car if the ride is being shared (Erhardt et al., 2019) and can induce travellers to shift from private car to public transport by providing better first and last mile connections to public transport services (Clewlow and Mishra, 2017, Rayle et al., 2016).

Moreover, ICT provide some of the passengers' needs such as integrated and electronic ticket services and convenient payment systems (Morfoulaki et al., 2015). Providing specific ICT-oriented features such as mobile ticketing and travel information, ICT has been found to stimulate public transport use among young passengers (Bąk and Borkowski, 2019). The reliance on ICT in daily life has largely reshaped young adults' transport needs and travel behaviour (Lyons, 2015). Thus, it has been suggested that ICT and the growth of the sharing economy contribute to the declining trend in car ownership among young adults (Bayart et al., 2020, Chatterjee et al., 2018, Rérat, 2018, van Wee, 2015, Delbosc and Currie, 2013).

1.1.2 Young adults' sustainable mobility in an ever-evolving digitalised world

Studies show a declining trend in young adults acquiring their driving licences in North America, Australia, UK and much of Europe (Chatterjee et al., 2018, Kuhnimhof et al., 2012a, Delbosc and Currie, 2013). For example, over the past 25 years, a major shift for males aged between 18 and 30 years old with delayed licence uptake, car ownership and use, and a reduction in distance travelled has been recorded in the UK (Marsden et al., 2018). Emerging research is beginning to explore the structural and demographic explanations for these trends. Popular hypotheses are the changing social status of the car (Delbosc and Currie, 2013), mobile phone use and overall attitudes to public transport (Julsrud and Denstadli, 2017), as well as the impact of environmental campaigns on available sustainable transport alternatives (Tuveri et al., 2020). Studies have also pointed out the influence of life stages on travel behaviour (Delbosc and Currie, 2013, Chatterjee et al., 2018). Chatterjee et al. (2018) found increased participation in higher education reduced the number of young people who require a car and increased public transport use while stable employment is associated with becoming a car driver. There remains uncertainty about whether young adults who use public transport might convert to car driving, as travel behaviours can change when moving from one life stage to another (Klöckner, 2004, Chatterjee et al., 2018).

Given the declining trend in car and driving licence ownership among young adults, changes to sustain and support this trend can be made to shift society towards less car dependent lifestyles (Marsden et al., 2020). Young adults' life stages such as starting studies and starting employment, have been found to influence their choice of transport mode (Klöckner, 2004). Therefore, the transition from university education to the workforce can be a window of opportunity to introduce measures to help young adults use public transport and shared mobility services, and so delay buying a car. Such measures include app-based mobility services for carsharing, bike sharing or ridesharing, which are becoming increasingly popular (Lopez-Carreiro et al., 2020). There is evidence that the adoption rate of these services is higher among young people, along with the regular use of smartphones for daily activities (Alemi et al. 2018, Clewlow and Mishra, 2017).

1.1.3 MaaS to shift mobility behaviour among young adults

As reported by Matyas and Kamargianni (2019), young adults' progressive attitudes towards ownership have supported the evolution of the sharing economy and the emergence of services such as Airbnb and Zipcar. In the field of transport, digitalisation has enabled the combination of mobility services with ICT to create a package of mobility solutions (Andersson et al., 2020) designed to shift peoples' travel patterns and reduce car dependency (Ahern, 2002, Caiati et al., 2020a). One evolutionary concept in the field of transport that supports a shift in travel behaviour is Mobility as a Service (MaaS). The service acts as a one-stop shop where different transport modes are combined into a subscription plan that can be accessed from a smartphone application (Karlsson et al., 2019). The transport options offered within MaaS are not limited to public transport, but intend to include taxis, carsharing, ridesharing and bike sharing, as well as other forms of mobility services. The aim of MaaS is to offer travellers flexible, reliable, and seamless door-to-door mobility based on their travel needs (Kamargianni et al 2016, Hensher, 2017, Hoerler et al., 2020, Hensher et al., 2021, Turner and Wilson, 2010). Due to the sharing nature of its available transport modes, MaaS has the potential to reduce the environmental impact of personal mobility.

A few examples of MaaS exist, and a few MaaS pilots have undergone trials with overall positive outcomes, such as the UbiGo study in Sweden (Karlsson et al., 2016). However, large-scale implementation has been slow (ITF, 2021). The first commercially available MaaS – Whim – was set up in Finland in 2016. There are other MaaS products around the world, such as WienMobil in Vienna, MobiCascais in Portugal, Citymapper PASS in London and MVGO in Munich. A few of these services are operated by the local public transport authority (e.g., WienMobil, MVGO, MobiCascais) or by private companies (e.g., Whim, Citymapper PASS). Several cities consider that a key benefit of MaaS is that it increases their citizens' accessibility to different available transport modes (Guidon et al., 2020, Caiati et al., 2020b).

Before introducing new transport services to the market, a precondition is to evaluate their appeal (Fu et al., 2019). Studies on MaaS are mostly limited to qualitative studies using questionnaires, interviews, and travel diaries from operational field tests (Sochor et al., 2014, Alyavina et al., 2020, Polydoropoulou et al., 2020), and reviews of MaaS schemes (Giesecke et al., 2016, Kamargianni et al., 2016, Jittrapirom et al., 2017) which indicate a set of expected MaaS early adopter user characteristics (Jittrapirom et al., 2017). Additionally, a few quantitative studies predict the potential demand for MaaS using discrete choice experiments with a focus on eliciting respondents' preferences towards alternative types of MaaS subscriptions (Caiati et al., 2020b, Matyas and Kamargianni 2017, Ho et al., 2020).

Proponents of MaaS claim it offers opportunities to reduce single occupancy car ridership, to improve utilisation efficiency of vehicles, and to encourage healthier transport alternatives such as walking and cycling (Jittrapirom et al. 2017). Yet its implementation has been hindered by challenges, including consumer acceptance (Catulli et al., 2020, Hoerler et al., 2020). Catulli et al. (2020) suggest communication strategies, simplification of access practices, and consumer education on MaaS benefits could be designed to target potential users. Target end users of MaaS are young people and professionals (Polydoropoulou et al., 2020); these groups are considered to be early adopters for their regular public transport use and flexible traveller characteristics when commuting or on business trips (Jittrapirom et al., 2020), as well as their use of technology. The millennial cohort adapted to the innovations of social media, constant connectivity and on-demand entertainment and communication as they came of age, and the post-millennial cohort were born in a technological environment (Dimock, 2019).

1.1.4 The impact of COVID-19 on travel patterns

The restrictive measures brought about by the COVID-19 pandemic have changed travel patterns and daily mobility decisions on a global scale (Eisenmann et al. 2021, Awad-Núñez et al., 2021, Hook et al., 2021, Barbieri et al., 2021). To slow down the spread of coronavirus and protect the health and well-being of citizens, countries around the world implemented lockdown measures and restrictions on travelling. Lockdown measures frequently involved the closure of non-essential shops and schools and working from home. Mitigation measures implemented often included rules on social distancing and mask mandates. New research reports how the pandemic and the lockdown impacted the use of transport modes, attitudes towards transport modes, and ownership of individual mobility options during lockdown periods.

Dingil and Esztergár-Kiss (2021) conducted an international survey to understand the relationship between the COVID-19 pandemic, transport systems and mobility patterns. The results show that active modes, motorcycle, and the personal car are perceived as the least risky urban transport modes. Thus, the authors found considerable growth in individual transport modes when compared to pre-pandemic commute and leisure trips. Similar results were found by Degli Esposti et al. (2021) in Italy and by Anke et al. (2021) in Germany. Both studies found safety concerns caused people to be less likely to use public transport and carsharing. Whereas a study by Hook et al. (2021) in Flanders, Belgium, found participants who cycled shifted to public transport. This was explained by participants taking advantage of the empty buses and trains. Similarly, Hook et al. (2021) found participants shifted from walking to using cars, taking advantage of less congested roads. A shift from public transport to other private transport modes, particularly for commute purposes, was barely recorded by Hook et al. (2021). The authors explain this in terms of the nature of the jobs of public transport users. Such jobs might have been halted during lockdown leading to a decrease in commute trips, or because of travel inequity where public transport users did not have access to other transport modes (Hook et al., 2021). Another shift in mobility was reported by Anke et al. (2021) based on German citizens' mobility behaviour in the early stages of the COVID-19 pandemic; regular users of public transport shifted to walking, cycling or driving, while users of other transport modes made no such change.

In the UK, Vickerman (2021) reported the use of private cars in cities decreased as people were urged to work from home, with the fear of infection likely to have led to greater use of private cars for short to medium term commuting during the recovery. The author concluded that a sustainable transport system in a post-pandemic world is unlikely to see a quick return to business-as-usual. Public transport use in all European countries has suffered as the number of users decreased massively during the strictest periods of lockdown, and never regained former levels when regulations were relaxed. Extra measures taken to provide a high level of hygiene in the vehicles also resulted in additional costs for transport operators (Eisenmann et al., 2021).

Awad-Núñez et al. (2021) collected both stated and revealed preferences of individuals in Spain to understand willingness to adopt and to estimate willingness to pay (WTP) for a set of measures to improve the safety conditions of public transport and shared mobility services. The results show that increasing supply and vehicle disinfection would increase participants' willingness to use public transport post-COVID-19. The provision of covers for handlebars and steering wheels also increases individuals' willingness to use sharing services, however participants expect to pay the same pre-COVID-19 prices. While the extent and duration of these changes remain uncertain, they have already had a great impact on travel patterns.

Although this thesis does not focus on the impacts of COVID-19, the measures imposed by the UK government caused a major contextual shift in the final stages of the data collection, and therefore the research design had to be amended to account for the ongoing changes. A timeline showing the progress of this thesis and the COVID-19 measures is provided in Chapter 3 Section 3.4.

1.2 Thesis aim and research questions

The overall aim of the thesis is to assess the role of MaaS as a potential tool for young adults to travel sustainably as they transition into the workforce and to inform MaaS product designers, employers and policy makers about key factors to enhance the appeal of MaaS to young adults transitioning into the workforce. Supporting this research aim is an objective to understand which psychological and travel attributes influence young adults' travel choices and travel behaviour including the influence of travel policies that were implemented during this research. Three research questions have been developed:

- **RQ1a**: What determines multimodal travel behaviour?
- **RQ1b**: Which psychological factors influence the use of public transport and shared mobility services?
- **RQ2**: What is the appeal of MaaS?
- **RQ3:** Which factors influence young adults' mobility decisions as they transition from university education to the workforce?

A mixed methods approach was adopted to address these research questions, which is discussed in Chapter 3.

1.3 Thesis contribution

This chapter has argued that young adults are delaying getting their driving licence and buying a car, but studies have shown that once students find a stable full-time job, mobility decisions often shift and they are more likely to start driving and buy a car. Thus, it is important to examine how to sustain young adults' commute patterns as they transition into the workforce. MaaS can be influential in helping young adults navigate public transport given they are both more open to using different transport modes and confident using smartphone technology.

The implications of this thesis can improve the effectiveness of travel behaviour interventions particularly with regards to MaaS, as decision makers can tailor strategies according to the characteristics of commuters in a particular setting. The following key contributions of this thesis, supplement existing literature:

- **The topic**, by focusing on MaaS and specifically examining young adults' perception of the app and its usefulness;
- **The study context,** which is focused on the city of Birmingham, UK as the first city to launch a trial MaaS app named 'Whim' by MaaS Global;
- **The data collection**, by creating a choice experiment where MaaS subscription plans are compared to other available public transport subscription plans and private car ownership; and
- **The focus on university – to – work transition** to identify the underlying factors that motivate and influence travel choice between life stages.

1.4 Structure of the thesis

This thesis is structured into seven chapters. A brief description and the purpose of each individual chapter is given in Table 1.

Table 1: Thesis structure

Chapter	Description	Purpose
1: Introduction	It provides the background and, motivations for this study and its importance, and also specifies the research questions to be addressed.	To introduce the purpose of this thesis.
2: Literature Review: Understanding travel behaviour for MaaS adoption	It synthesises the literature related to travel mode choice and comprehensively discusses the existing literature concerning behavioural theories and frameworks used to predict and promote sustainable mode choice behaviour. It concludes on the research gaps that this thesis aims to address.	To identify the research gaps that this thesis aims to address.
3: Research Methodology and Methods	It presents the overall research design and strategy applied to address the research questions and includes a description and justification of the study's context.	To justify the selection of research methods and to outline the sampling strategy.
4: Commuters' Intent to use MaaS	It presents the methodology, data, analysis, and findings of the questionnaire survey.	To identify multimodal travel behaviour and intention to use public transport and shared mobility services.
5: Commuters' Preference for MaaS	It presents the methodology, data, analysis, and findings of the stated choice experiment.	To determine the attractiveness of MaaS when compared to other available travel subscription plans, and private car ownership.
6: Mode Choice during the University-to-Work Transition	It presents the methodology, data, analysis, and findings of the semi-structured interviews.	To identify the underlying factors that motivate and influence graduates' travel choices as they transition from university education to the workforce.

Chapter	Description	Purpose
		To explore the role of MaaS as a potential tool considering travel policies in Birmingham, UK.
7: Discussion and Conclusion	It syntheses the results of the three empirical chapters and provides insights for MaaS product designers, employers, and policy makers. The concluding section summarises the key findings and suggests possibilities for further research.	To interpret the results to ensure a meaningful and constructive contribution.

Chapter 2 Literature Review: Understanding travel behaviour for MaaS adoption

This chapter reviews the current literature available on travel behaviour particularly that of young adults compared to the general population. The concept of MaaS is still in its infancy therefore to study the potential adoption of MaaS, literature on travel behaviour and mode choice were reviewed. The chapter has three main sections. The first section focuses on travel behaviour and mode choice. This section concludes with identifying the theories and frameworks to understanding travel behaviour for potential MaaS adoption. The second section reviews the current literature on young adults' travel behaviour and concludes by identifying factors influencing young adults' shift in travel behaviour. The chapter concludes with the introduction of a potential mobility tool to facilitate young adults' sustainable transport choices.

2.1 Travel behaviour and mode choice

Inducing modal shift away from the private car is one of the pressing concerns of transport geography and policy (Kent et al., 2017). If mode choice is left unaddressed increased levels of private car use will lead to even greater levels of congestion and air pollution in urban areas. However, motivations underlying travel mode use may reflect transport priorities. This means individuals focus and prioritize certain attributes in the choice of travel mode use (Şimşekoğlu et al., 2015). Hence, the underlying factors determining mode choice need to be studied to elicit travellers' preferences. Long-established mode choice models, predicting travel mode choices, are based on the principle of random utility maximization (Xie et al., 2003). Mode choice is defined as being 'the decision process to choose between different transport alternatives, determined by a combination of individual sociodemographic factors and spatial characteristics and influenced by socio-psychological factors' (De Witte et al., 2013). However, modal choice is not always the result of a choice. An individual can be restricted in their choice of travel mode because of limited access as well as personal attitudes, perceptions, preferences, or habits. According to Zhou et al. (2012) the factors that influence mode choice for the general population are personal characteristics, psychological factors, trip characteristics, mode specific attributes, the built environment and infrastructure and the presence of Travel Demand Management (TDM) measures.

Therefore, this section introduces the theory, behaviour and methods chosen to understand young adults' intentions to use MaaS and the challenges and opportunities of having a MaaS for young adults' transition into the workforce. The Theory of Planned Behaviour addresses the subjective factors influencing travel behaviour and mode choice, whereas discrete choice models use objective factors such as travel cost, time and waiting time as factors influencing travel behaviour and mode choice. Meanwhile the Capability, Opportunities, and Motivation Behaviour model addresses the complex interplay between individual, social, and environmental factors influencing travel behaviour and mode choice.

2.1.1 The Theory of Planned Behaviour

Behavioural models are used to understand and represent what consumers do and why (Axsen and Kurani, 2012) and to explain travel choices from a socio-psychological perspective (Busch-Geertsema and Lanzendorf, 2017). The Theory of Planned Behaviour (TPB) by Ajzen (1991) is one of the most well-established psychological models used to predict mode choice (Anable, 2005, Chowdhury and Ceder, 2016, Lanzini and Khan, 2017, Heath and Gifford 2002). The TPB has been applied and extended successfully to predict intentions of using different transport modes (Haustein and Jensen, 2018) such as public transport (Ambak et al., 2016, Bamberg et al., 2003, Nordfjærn et al., 2014), cycling (Lois et al., 2015), the private car (Anable, 2005, Abrahamse et al., 2009, Kerr et al., 2010), walking (Williams et al., 2015) and carshare (Jain et al., 2021, Zhang and Li, 2020).

The TPB is an extension of the Theory of Reasoned Action (TRA) (Ajzen, 1991) by including measures of perceived behavioural control. The TRA assumes that behaviour occurs under volitional control. This means behavioural intention is regarded as the motivation necessary to engage in a particular behaviour. Ajzen (1991) explains how the TRA was limited in dealing with behaviours over which people have incomplete volitional control. The lack of certain skills and knowledge, finance and time can prevent people from acting on intentions to perform a behaviour (Ajzen, 2020). Hence, the TRA model was revised to include the construct of control, calling the revised model the TPB. This means the behaviour is successful if the person has the required opportunities and resources and intends to perform the behaviour (Ajzen, 1991).

The TPB (Figure 1) predicts the intention to perform a behaviour from attitudes, subjective norms, and perceived behavioural control (PBC). Attitude is defined as the degree to which the performance of the behaviour is positively or negatively valued, subjective norms is the perceived social pressure to engage – or not – engage in a behaviour and the PBC refers to an individual’s perception of their ability to perform a behaviour (Ajzen, 1991). Actual behaviour is determined by the intention to perform the behaviour together with the individual’s PBC (Ajzen, 1991). Each of the three TPB variables have formative indicators identifying the specific beliefs that contribute most to the three predictor variables. However, these are only included in the analysis when the goal of the research is to focus on understanding one of the predictors, allowing for a detailed exploration of the components of the chosen predictor.

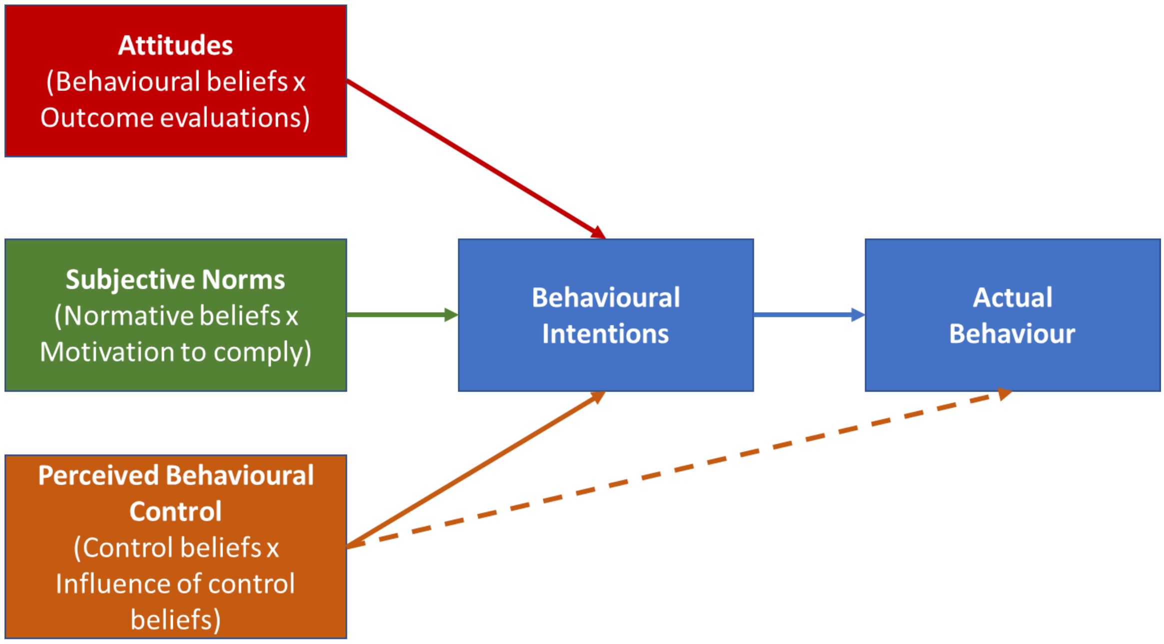


Figure 1: The Theory of Planned Behaviour (Ajzen, 1991)

Despite several studies confirming the efficacy and robustness of the TPB in predicting intention and behaviour using the original variables (Heath and Gifford, 2002, Armitage and Conner, 2001), the TPB is criticised for not including situational and spatial factors (Busch-Geertsema and Lanzendorf, 2017). Chen et al. (2020) explained travel mode choice may not be determined only by self-intention but also by other external factors such as cost and accessibility, which can be taken into account in TPB if, formative indicators of attitudes are considered (behavioural beliefs such as ‘public transport is expensive’), or if TPB is combined with utility variables in a latent choice model. Researchers have modified the TPB to improve the explanatory power of the original TPB variables (Heath and Gifford, 2002). The most common inclusions for travel mode choice have been habit (Anable, 2005, Bamberg and Schmidt, 2003, Donald et al., 2014, Verplanken et al., 1998) and the individuals’ pro-environmental attitude (Nilsson and Küller, 2000). Still, the TPB with its original variables offers a comprehensive and economical model to explain mobility behaviour with the limited resources of survey studies (Hunecke et al., 2007).

A systematic review of the use of the TPB in the transport literature can be found in Hoffman et al. (2017). After conducting a meta-analysis on the cognitive mechanisms predicting travel mode choice, Hoffman et al. (2017) found the strongest correlates of alternative transport choice were intentions, PBC and attitudes. The meta-analysis also reported the underpinning beliefs of attitudes used in many of the studies. These were related to safety, convenience, time flexibility, practicality, health, accident risk and comfort (Hoffman et al., 2017). With reference to subjective norms, studies by Zailani et al. (2016) and Donald et al. (2014) found respondents reported strong subjective norms for using public transport to work. As regards to the PBC, the impact of an individual's PBC on mode choice was reported by Busch-Geertsema and Lanzendorf (2017) who found individuals were more likely to change travel mode if their PBC of public transport and of non-motorised modes was high. Similarly, Hunecke et al. (2007) found the use of private motorised modes highly depends on peoples' perception of their ability to use public transport.

A factor which is related to the use of multiple modes of transport within one journey is transfer routes. Chowdhury and Ceder (2013) used the TPB to predict the use of public transport transfer routes and found public transport users needed to have a strong PBC when deciding to make the transfers. PBC was defined by public transport users' perception of trip attributes such as personal safety, information, reliability of connection, transfer waiting time and transfer walking time.

Transferring between multiple modes to complete a journey is considered inconvenient and has been shown to influence traveller's decision to use public transport (Guo and Wilson, 2004, Ceder, 2016). Heinen (2018) explains how increased policy attention has been placed on encouraging a partial shift instead of a full modal shift, meaning the mixed use of different transport modes which is known as multimodal travel behaviour. Thus, individuals are labelled multimodal travellers when they use two or more transport modes within a period of time. The period of time used by a number of studies include (1) multi-week travel surveys (2) weeklong travel surveys and (3) one-day travel surveys with questions about travel during longer time periods (Kuhnimhof et al 2006, Nobis 2007). Most studies suggest that survey periods of one week tend to capture typical variability in everyday habitual travel behaviour (Block-Schachter 2009, Kuhnimhof et al 2006, Nobis 2007). Longer multi week survey periods additionally capture occasional travel behaviour (Schlich and Axhausen 2003). In addition, the transport modes included in the measurement vary. Some studies of multimodality exclude ‘walking’ as a transport mode based on the assumption that survey respondents often forget to report short walk trips (Kuhnimhof et al., 2006, Nobis 2007).

2.1.2 Multimodal travel behaviour

The measurement of multimodality is complex and needs to consider both the modal mix of transport modes used as well as the frequency that each mode is used (Heinen and Mattioli, 2019). Lin et al. (2019) measured multimodality by the number of unique modes used for a random day, using a travel diary. Nobis (2007), Buehler and Hamre (2015) and Kuhnimhof et al. (2012b) relied on one-week travel diary data and Vij et al. (2013) used six-week travel diary data. Diana and Mokhtarian (2009) considered a longer time period by relying on self-reported frequency of use of various modes over the course of a year measured on five-point ordinal scales. Although self-reported survey data are less detailed than diary data, these have the advantage that much longer time periods can be considered. A straightforward approach to measuring multimodality was described by Molin et al. (2016), where multimodal travellers were identified using a self-reported frequency of different transport modes, measured on an ordinal scale running from every day to less than once a year.

Engaging in multimodal travel behaviour is thought to strengthen the presence of newly emerging mobility services such as car and bike sharing and to provide an attractive alternative to the private car (Klinger, 2017). Combining or replacing the private car with car and bike sharing options can contribute to a reduction in car ownership and use (Klinger, 2017). These assumptions are supported by initial indications of a more multimodal organisation of urban transport in many western cities. New mobility services are well established in many metropolitan regions (Shaheen and Cohen, 2007, Shaheen et al 2010) and are increasingly integrated in existing public transport systems, e.g., by multimodal booking and information options. Thus, the increasing digitalisation of transport services facilitates new travel behaviour patterns, including the more flexible and spontaneous combination of different transport modes.

Multimodality is gaining recognition as an important mechanism for reducing car dependency by shifting trips from personal vehicles to walking, cycling, or public transport (Buehler and Hamre, 2015, Heinen and Mattioli, 2019). Identifying the characteristics of multimodal users can lead to identifying potential determinants of multimodality (Heinen and Mattioli, 2019). In a study by Heinen and Chatterjee (2015) the factors chosen to measure modal variability in Great Britain were inspired by Hägerstrand (1970). Hägerstrand (1970) identified three time-geographic constraints specifying what hinders individuals from performing activities. Heinen and Chatterjee (2015) defined capability, coupling and authority constraints to describe how individuals are limited in their spatial (travel) behaviour (Table 2).

Table 2: Multimodality constraints identified by Hägerstrand (1970) and defined by Heinen and Chatterjee (2015)

Hägerstrand (1970)	**Constraints**	**Definition**	**Examples**
Capability constraints	Physical	these influence capabilities of participating in certain activities as well as the ability to use certain modes.	• Mobility difficulties • Driving licence possession
Coupling constraints	Social Role	these influence role responsibilities, activity requirements and time availability.	• Gender • Ethnicity • Age • Having a child in the household
	Work	these influence the amount and pattern of commuting required and the time remaining to participate in other activities which may influence the opportunity to use multiple modes.	• Economic status • Self-employment • Working location
Authority Constraints	Accessibility	these influence distance required to travel to destinations and physical context for these journeys, as well as transport options available.	• Settlement type • Housing type • Housing tenure • Access to public transport
	Economic	these influence economic resources available for mobility.	• Income • Social-economic status
	Mobility	these influence opportunity and commitment to use particular transport modes.	• Car access • Having a public transport pass/season ticket • Bicycle ownership

Research studies have mainly used sociodemographic variables such as gender, age and education, and mobility access variables including car ownership, bicycle ownership and driving licence holding or penetration to distinguish between different types of multimodal travel behaviours (Molin et al., 2016, Buehler and Hamre, 2015, Heinen and Chatterjee, 2015). Studies have shown how multimodal travel is associated with young people, small households and having a high level of education (Molin et al., 2016, Buehler and Hamre, 2015, Scheiner et al., 2016). Molin et al. (2016) used attitudinal variables to group different multimodal users. The authors found the public transport multimodal group to be composed of young adults with a low income and with an unexpectedly favourable attitude towards car driving. Thus, Molin et al. (2016) believe the young group members of the public transport multimodal group would start using the car more often once they can afford it. The use of the car with other transport modes was also reported by Buehler and Hamre (2015). The authors found higher levels of multimodal car use among individuals with a higher level of education suggesting individuals who had attended university were familiar with alternative transport modes. Hence, young adults attending university may be inclined towards multimodality even if they decided to get a driving licence and own a car. Other predictors of multimodality were living in large urban areas and having better public transport access (Scheiner et al., 2016, Buehler and Hamre, 2015). These predictors are synonymous with young adults moving to urban areas for reasons of employment, improved public transport, not being dependent on a car and preferring an urban lifestyle (Chatterjee et al., 2018). Meanwhile, factors associated with a low uptake of multimodality were found to be full-time employment and households with young children (Scheiner et al., 2016, Nobis, 2007).

A successful public transport system is expected to achieve the level of convenience of a door-to-door service that a private car offers (Guo and Wilson, 2007). The provision of an integrated information system offering comfortable transfers would encourage public transport ridership (Chowdhury and Ceder, 2013). Using public transport involves walk time, wait time, and fare payment, however with a transfer this involves extra time and payment (Guo and Wilson, 2007). These travel mode attributes have been used in discrete choice experiments (DCEs) to determine an individual’s choice of transport mode. Using Lancaster’s economic theory of value (Lancaster, 1966), DCEs assume individuals derive utility from the underlying attributes of the commodity rather than the commodity per se, for example, from the attributes of a private vehicle such as safety, speed, mileage and not the private vehicle per se. Therefore, it is assumed that an individual’s preferences are revealed via their choices.

2.1.3 Discrete choice models

Transport researchers can get information on consumers' preferences for different travel modes through revealed preference and stated preference surveys. The one fundamental difference between a revealed and stated preference survey is that a revealed preference survey asks a traveller what they actually did, while a stated preference survey asks respondents what they would do in a hypothetical situation. Thus, revealed preference models describe actual behaviour and stated preference data are elicited from hypothetical choice experiments (Yan et al., 2019).

The DCE is based on the Random Utility Theory and proposes that individuals strive for utility maximisation (Louviere et al., 2010). The decision maker is provided with choice tasks that consist of different alternatives where each alternative is described by several attributes and levels which change between one choice task and another. The models from the experiments have been used by researchers to model consumer choice behaviour in a variety of studies: transport, energy, food consumption and marketing (Cirillo and Xu, 2011, Kim et al., 2018, Contini et al., 2017, Dubé et al., 2002). Such quantitative experiments have also been used to gather information about products and services that are not yet available on the market (Louviere et al., 2000, Weber, 2019, Yan et al., 2019). However, predicting the adoption of an unfamiliar transport mode can be challenging (Chavis and Gayah, 2017).

Considering transport is to undergo radical changes in the near future due to the digitalisation of transport (Weber, 2019), stated preference surveys are an appropriate method to elicit demand for hypothetical markets, for instance to gauge the demand for new transport systems. This at least partly explains why stated preferences studies have been increasingly popular in investigating the demand for new modes since revealed preference surveys cannot be used before a new mode is available (Yan et al., 2019). The literature below discusses how stated preference approaches made provisions about which attributes of the new innovative transport technologies and their alternatives were deemed important.

Discrete choice experiments using conventional and innovative transport modes

Several studies have used DCEs to elicit respondents' choice for a particular travel mode among a given selection of conventional transport modes and/or innovative transport technologies. The aim for conducting DCE in the transport literature is varied. Studies that used existing conventional transport modes as alternatives aimed to examine participants' preferences and ratings on the level of service attributes (De Palma and Rochat, 2000, Alpizar and Carlsson, 2003, Loria et al., 2019). Other studies examined the inclusion of shared services such as carsharing and ridesharing combined with the public transport system. The inclusion of such services was done to replace underutilised routes and therefore improve operational efficiency by providing a last-mile connectivity to extend a public transport catchment area (Yan et al., 2019, de Luca and Di Pace, 2015). Yan et al. (2019) and Arentze and Molin (2013) studied the introduction of an integrated transport system to examine the main determinants of mode choice. Catalano et al. (2008) and Chavis and Gayah (2017) examined carsharing and flexible transport route services. Studies examining highly innovative transport options include urban air mobility (UAM) using an autonomous flying taxi (AFT) (Fu et al., 2019) and trips provided by an autonomous taxi, autonomous train, and autonomous car (Stoiber et al., 2019).

Researchers using DCEs report that socio-economic variables such as gender, age and income have effects on the propensity to travel by conventional car or public transport. Using a university campus context, Yan et al. (2019) found students more likely to choose public transport over driving a car, and faculty and staff more likely to drive when having a higher household income. Gender was also found to determine mode choice. Yan et al. (2019) and Zhou (2012) found females were less likely to walk or bike than males while Danaf et al. (2014) found male students were more likely to use the bus compared to female students. Furthermore, the authors found gender, income, residence location and car ownership to affect the mode choice made by students, whereas the factors of gender, age, income, and residence location were not found to be significant for the general population. The importance of residential location, explained by an individual being able to walk, bike or take the bus to places, was found in Yan et al. (2019) as a significant predictor of mode choice. Similarly, De Palma and Rochat (2000) found accessibility to be influential for respondents to favour the use of the car.

In addition to socio-economic variables, Khan (2007) explained how consumers made decisions based on the characteristics of the different travel modes on offer such as travel times, costs, and other level of service attributes. The utility of a certain transport mode for an individual is a measure of the attractiveness or potential of the mode for a specific trip, defined by the attributes of in-vehicle travel time, time to access the transport mode and waiting time (Ben-Akiva and Lerman, 1985). Research studies have shown how the two most prominent attributes that influenced the utility of certain transport modes were the travel time and cost of the mode (Cox, 2015, DePalma and Rochat, 2000, Choudhury et al., 2018). Studying students and the general population, Danaf et al. (2014) found students from high income households to have a higher value of time compared to the general population which was explained by the tight schedules and class attendance requirements where a class session with a duration of one-hour costs students much more than what a typical employee earns per hour in the study area of Beirut. Yan et al. (2019) found participants to value out of vehicle travel time and waiting time more than in-vehicle travel time. This suggests reducing out of vehicle travel time and waiting time could be more effective than reducing in-vehicle travel time to enhance the desirability of a trip by public transport and ridesourcing services. Another significant predictor was cost with Arentze and Molin (2013) distinguishing between types of costs. The authors found respondents to be highly sensitive to ticket prices and parking fees and less sensitive to fuel costs. Other studies also found respondents to be sensitive to cost (Chavis and Gayah, 2017, Arentze and Molin, 2013, Loria et al., 2019) especially for the modal split choice between car and public transport (DePalma and Rochat, 2000, Alpizar and Carlsson, 2003).

Research studying the role of emerging transport technologies competing with existing transport options were conducted by Stoiber et al. (2019), Chavis and Gayah (2017) and Fu et al. (2019). The latter found respondents with a higher value of time were more willing to accept autonomous transport modes. A critical determinant for the adoption of autonomous vehicles (AV) and AFT was safety (Fu et al., 2019). As expected, the market penetration rates for such mobility services were found to be greater among young participants. Participants who reported to use public transport or active modes most frequently were less likely to favour any autonomous modes. Stoiber et al. (2019) found travel cost, waiting time, travel time and reliability as important factors affecting mode choice. However, for both short term and long-term mobility decisions, Stoiber et al. (2019) found a higher acceptance rate for shared autonomous services over privately owned autonomous car.

Fu et al. (2019) highlighted the importance of evaluating new mobility services together with currently available urban transport modes to understand the choice behaviour of potential users. However, as reported by Stoiber et al. (2019) and Chavis and Gayah (2017) participants were found to select options similar to the conventional technology they knew rather than rating their potential acceptance of using sharing or pooling options with flexible transport routes. This shows how predicting the demand for new mobility services which are unfamiliar to participants can be challenging.

Table 3 presents the studies reviewed listing the travel mode attributes used and determinants of mode choice.

Table 3: Studies using discrete choice experiments for conventional, shared mobility, and innovative transport technologies

Authors	Type of transport mode(s) as alternatives	Location	Participants	Aim	Choice task alternatives	Attributes	Determinants of mode choice
De Palma and Rochat (2000)	Conventional transport modes	Geneva, Switzerland	Employed persons in private companies	Mode choice for trips to work defined by the decision of how many cars to own in the household and the decision to use the car for the trip to work.	• Public Transport • Private Car	• Comfort • Availability • Travel time (minutes) • Cost	Travel time and cost found to play a key role in modal split choice between car and public transport. Perceived level of comfort and accessibility of modes influence the modal split choice. Car ownership is related to the income level of the household and the number of working people in the household as well as location issues.
Alpizar and Carlsson (2003)	Conventional transport modes	San Jose, Costa Rica	Individuals with work that have access to a car, living and	Given fixed house to work structures and no working hour flexibility, by how much is the	• Car • Bus	Car alternative • operating costs • travel time per trip • parking cost	Travel time for both modes and travel cost for car are the most important determinants of mode choice.

Authors	Type of transport mode(s) as alternatives	Location	Participants	Aim	Choice task alternatives	Attributes	Determinants of mode choice
			working in the metropolitan area of San Jose.	choice of travel mode for commuters to work sensitive to changes in travel time, changes in costs for each mode and other service attributes?		Bus alternative • travel time • bus fare per trip • punctuality • distance to bus stop • frequency of departures • comfort and security	
Loria et al. (2019)	Conventional transport modes	Aberdeen, Scotland	Local bus users in Aberdeen City	Investigate bus users' preferences for emission reduction in bus travel	• Diesel Bus • Hydrogen Bus	• Frequency • Comfort • Driver friendliness • Punctuality • GHG emissions • Nitrogen oxides and particulate matter • Fare	Bus users place a higher value in the reduction of local pollutants over GHG emissions. Increasing experience using a hydrogen bus has an effect on preferences for the comfort and bus emissions attributes. Females care more about comfort.

Authors	Type of transport mode(s) as alternatives	Location	Participants	Aim	Choice task alternatives	Attributes	Determinants of mode choice
							Bus users prefer cheap, fast, and reliable buses.
Arentze and Molin (2013)	Conventional transport modes with multimodal trips including car and public transport	Netherlands	Large national panel in Netherlands.	Estimation of preference parameters related to the trade-off between uni-modal trips and multimodal combinations of private (PV) and public transport modes with varying distances (5km, 20km, 65km).	• Car • Bicycle • Public transport (PT) • Combination of private (car, bicycle) and public transport	Multimodal 5km distance Private Bicycle • Main travel time Private Car • Main travel time • Parking search time • Walk to destination • Possible delay • Travel costs • Parking costs Bus, tram, local train • Access time walking • Wait for public transport	The journeys with the least cost are the most preferred paths of travellers. Cost sensitivity is higher for ticket prices and parking fees and lower for fuel costs. Travelers with a car option need a strong compensation before they are willing to use less convenient public transport and park and ride facilities. Public transport is less attractive when seat availability is uncertain and reliability is limited with the

Authors	Type of transport mode(s) as alternatives	Location	Participants	Aim	Choice task alternatives	Attributes	Determinants of mode choice
						• Main travel time • Walk to destination • Possible delay • Travel costs one way Multimodal 20km distance Private car • Main travel time • Parking search time • Walk to destination • Possible delay • Travel costs one way • Parking costs Bus, local train, and intercity train • Access time walking • Main travel time	possibility of a delay.

Authors	Type of transport mode(s) as alternatives	Location	Participants	Aim	Choice task alternatives	Attributes	Determinants of mode choice
						• Transfer time • Walk to destination • Possible delay • Travel costs one way Private car and public transport • Car detour travel • Transfer time • Next public transport travel time • Parking search time • Parking costs	
Yan et al. (2019)	Conventional transport modes with ridesharing service	United States of America	Faculty members, staff members and students from	Examine determinants of commuting mode choice using an integrated transport system	• Drive a car • Ride with MTransit • Bike • Walk	• Total travel time (including time in walking, waiting, and finding parking) • Walking time • Waiting time	Individuals tend to value out of vehicle travel time and wait time more than in vehicle travel time.

Authors	Type of transport mode(s) as alternatives	Location	Participants	Aim	Choice task alternatives	Attributes	Determinants of mode choice
			the University of Michigan	named MTransit on a university campus		• Time in finding parking • Transfer(s) • Additional pickup(s)	Strong resistance to transfers and additional pickups. Income and vehicle access contribute to driving. Residential preference of moving to a place where one can walk or bike or take the bus to places predicts mode choice.
Danaf et al. (2014)	Conventional transport modes with ridesharing service	Beirut	Students from the American University of Beirut and the general population of Greater Beirut Area	Using a DCE to model mode choice of students and the general population and forecast students commute mode share	• Car • Bus • Shared taxi (or jitney)	• Travel time • Travel cost • Parking access	Gender, age, income, and residence location were not significant for the general population. Only time and cost were found to be determinants of mode choice. Students from higher income households are more likely to use car

Authors	Type of transport mode(s) as alternatives	Location	Participants	Aim	Choice task alternatives	Attributes	Determinants of mode choice
							compared to bus and jitney and to use jitney compared to the bus. Student males are more likely to use the bus and have a lower preference for car than for jitney. Students from high income households have a higher value of time than the general population.
Catalano et al. (2008)	Conventional transport modes with ridesharing and carsharing services	Palermo, Italy	Employees, university students and self-employed workers commuting daily towards the city centre	Travel mode choice behaviour for workers and students commuting urban trips	• Private car • Car pooling • Car sharing • Public transport	• Transport hourly cost (£/h) for carsharing and transport kilometric cost (£/km) for carpooling, private car, carsharing, the transport cost per one-way trip	A reduction in in-vehicle time and waiting time and improvement in the public transport service would increase the demand for carshare and carpool services.

Authors	Type of transport mode(s) as alternatives	Location	Participants	Aim	Choice task alternatives	Attributes	Determinants of mode choice
						(£/trip) for public transport • The parking cost per one-way trip (£/trip) for private car, carpooling and carsharing • Time spent to move from the origin zone to the destination (minutes) for all the alternatives however for public transport this time attribute includes the waiting time spent at the bus stop	To increase the demand for carpool and carshare services specific parking areas for such users would help as well as rising parking fees and closing the city centre for high emission vehicles.

Authors	Type of transport mode(s) as alternatives	Location	Participants	Aim	Choice task alternatives	Attributes	Determinants of mode choice
						• Parking time (minutes) for car, carpooling, and carsharing • Access time (minutes) for all the options, which is the time spent for moving from one's house to the starting point of the trip (parking lot, carsharing centre, bus stop)	
Chavis and Gayah (2017)	Conventional transport modes with flexible route ridesharing services	Baltimore, Maryland, United States	Respondents located at a major transit hub, Mondawmin and downtown at	Mode choice model to describe how transit users select emerging competitive transit options	• Fixed route (a traditional bus) Flexible route (van or bus with a route that deviates from a fixed route)	• Walking time • Waiting time • In-vehicle travel time • Cost • GPS availability	Socio-economic and attitudinal variables do not add much improvement to the models.

Authors	Type of transport mode(s) as alternatives	Location	Participants	Aim	Choice task alternatives	Attributes	Determinants of mode choice
			the Inner Harbour		• Individual (taxi or similar service where individual(s) is driven directly from their origin to a destination with no intermediate stops)		Monetary cost, expected in-vehicle waiting time, expected waiting time and walking time were statistically significant predictors of the type of flexible transit option selected.
Fu et al. (2019)	Conventional transport modes with autonomous taxi and flying taxi vehicles	Munich, Germany	Active commuting population 18 years or older from the Munich metropolitan region	Investigates the transport mode preferences and notably, the adoption of AFT and UAM by estimating the potential influence of service attributes	• Autonomous flying taxi (AFT) • Public transport (bus, tram, U-bahn, S-bahn of the region) • Private car (driver) • Autonomous taxi (AT)	• Total travel time • Total travel cost/fare • Safety level • Inconvenience indicated by total walking time and/or waiting time • Multitasking possibility	Respondents with a higher value of time are more willing to accept autonomous transport modes. Safety may be a critical determinant of adoption of AVs and AFT. No difference between gender.

Authors	Type of transport mode(s) as alternatives	Location	Participants	Aim	Choice task alternatives	Attributes	Determinants of mode choice
				which may affect people's choices among given transport alternatives and identifying the characteristics of the potential user groups with higher propensity to accept AFT and UAM services.			Market penetration rates for AFT and UAM may be greater among younger respondents (18-35 years old) Older travellers (56-65) with high income have a high propensity to use AT. AFT and UAM desirable for performing business trips rather than for daily commutes. Lower income and lower education levels less likely to accept AFT. Employed individuals aged 56 to 65 years old prefer autonomous transport services.

Authors	Type of transport mode(s) as alternatives	Location	Participants	Aim	Choice task alternatives	Attributes	Determinants of mode choice
							Participants belonging to the high-income group without children tend to favour AFT. Respondents currently using public transport or soft modes (walking or cycling) most frequently are less likely to favour any autonomous modes.
Stoiber et al. (2019)	Autonomous conventional transport modes	Switzerland	Swiss Household Energy Demand Survey respondents	Experiment testing the likelihood of users choosing different modes of autonomous vehicles with increasing degrees of pooling, privately owned autonomous cars,	Short term decision • Trip by privately owned autonomous car • Trip by autonomous taxi • Trip by autonomous shuttle/train	Short term decision • Price • Walking distance • Vehicle used with others • Number of persons in vehicle • Level of reliability • Waiting time • Travel time	Both for short term and long-term decisions a higher acceptance rate for shared autonomous services over privately owned autonomous car. Travel cost, waiting time and travel time produced significant effects.

Authors	Type of transport mode(s) as alternatives	Location	Participants	Aim	Choice task alternatives	Attributes	Determinants of mode choice
				pooled use autonomous taxis and autonomous public transport shuttles for mobility decisions taken in the short term (visiting a friend) and long term (relocating for a job offer).	Long term decision Buying an autonomous car • Subscription to an online platform of autonomous taxis • Buying a general public transport pass with autonomous shuttle door-to-door services	Long term decision • Investment • Variable km price • Vehicles used with others • Walking distance • Maximum waiting time till service	Comfort factors like reliability are important factors affecting mode choice.

2.1.4 Capability, Opportunity, and Motivation Behaviour model

This review has so far shown how the behavioural model of the TPB can be used to predict behavioural intention to engage in a particular behaviour and DCEs to measure the influence of travel mode attributes on mode choice. Both the TPB and DCE use a set of parameters to understand mode choice failing to account for the complex social and physical environments in which behaviour occurs. Traditional choice models are criticised for not considering the heterogeneity of human behaviour, attitudes, and preferences (Ababio-Donkor et al., 2020). Manski (1973) explained how the predictions of some traditional choice models were irrational and studied the inclusion of attitudinal and behavioural variables to account for the subjectivity of human behaviour in choice models. The TPB has also attracted considerable amount of criticism for excluding personal and external influences on behaviour (Busch-Geertsema and Lanzendorf 2017). Busch-Geertsema and Lanzendorf (2017) examined the mode use of students before and after starting their employment using the Requirements, Opportunities, Abilities (ROA) approach (Harms, 2003) with the TPB. Using the ROA meant additional factors like personal life situation and surrounding mobility conditions could be identified together with the TPB to explain travel behaviour.

Busch-Geertsema and Lanzendorf (2015) explain how the ROA approach is derived from the Motivation, Opportunity, and Ability (MOA) model by Ölander and Thøgersen (1995) and the Needs, Opportunities, and Abilities (NOA) model by Vlek et al. (2000). Harms (2003) defines mobility requirements as subjectively perceived mobility demands at the individual level such as time or distance constraints. Mobility opportunities refer to environment-related and external facilitating conditions such as the availability and accessibility of goods or services. Mobility abilities are defined as the legal, physical, or financial means that enable a person to perform a behaviour (Harms, 2003). Thus, the ROA components are derived from personal and mobility conditions. In their study, Busch-Geertsema and Lanzendorf (2017) suggest abilities and opportunities influence the PBC, while the requirements and opportunities affect the attitude towards the behaviour.

A new approach for understanding behavioural choices is the Capability, Opportunity, and Motivation Behaviour (COM-B) model (Michie et al., 2014). The COM-B model stipulates that for individuals to engage in a particular behaviour (B), they must have sufficient capability (C), opportunity (O) and motivation (M) (Michie et al., 2014). Using the COM-B model allows the researcher to understand the behaviour in the context in which it occurs meaning behaviours are determined by a complex interplay between individual, social, and environmental factors.

Figure 2 shows how the different components of the COM-B model interact. The following are explanations by Michie et al. (2014) on how each component explains the behaviour:

1. There must be the ‘capability’ to do it: the person or people concerned must have the physical strength, knowledge, skills, and stamina to perform the behaviour;
2. There must be the ‘opportunity’ for the behaviour to occur in terms of a conducive physical and social environment: example it must be physically accessible, affordable, socially acceptable and there must be sufficient time; and
3. There must be sufficient strong ’motivation’, i.e., they must be more highly motivated to do the behaviour at the relevant time than not to do the behaviour, or to engage in a competing behaviour.

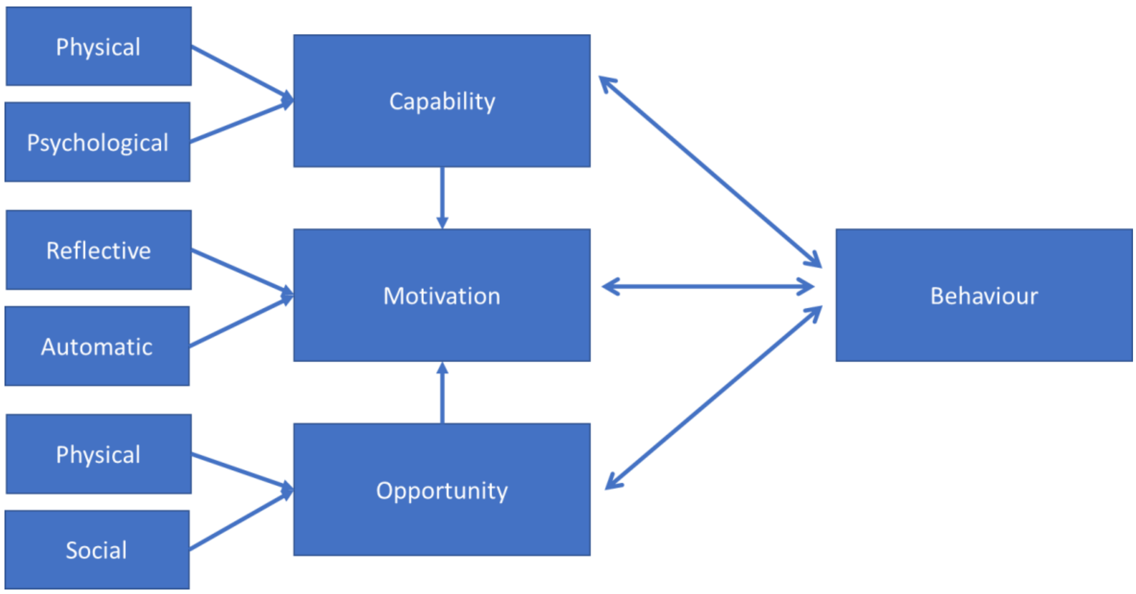


Figure 2: The COM-B model - a framework for understanding behaviour (Michie et al., 2011)

If more detail is needed to understand the behaviour, the COM-B model components can be further elaborated using the Theoretical Domains Framework (TDF) (Michie et al., 2014). The TDF is made up of 14 domains which help unpack the COM-B model further and allow deeper exploration for understanding the behaviour (Cane et al., 2012). Explicit links between the TDF domains and the COM-B model are given in the Behaviour Change Wheel (BCW) Guide (Michie et al., 2014). Table 4 presents the COM-B model components linked to the TDF domains including the definitions for each domain and theoretical constructs explaining each domain as presented in Michie et al. (2014).

Similarities can be found between the COM-B model and the time-geographic constraints of capacity, coupling and authority identified by Hägerstrand (1970). Capacity constraints relate directly to the individual's abilities, properties, knowledge, and available tools to perform the behaviour. Authority constraints relate to rules, laws, agreements, and regulations that are to be followed by individuals in an organisation or the society as a whole. Coupling constraints include the necessity to couple individuals to each other in the time-space in order for them to successfully perform an activity. Heinen and Chatterjee (2015) defined the time-geographic constraints in terms of travel behaviour. Physical mobility constraints are an individual's capability to participate in certain activities as well as the ability to use certain modes. Coupling constraints are the responsibilities, activity requirements and time availability attached to an individual's social and professional roles. Authority constraints are an individual's level of accessibility, transport options available and their financial situation.

In comparison to the COM-B model, the capability time-geographic constraint is characterised by the physical and psychological capability component and the reflective motivation component. The coupling time-geographic constrain is characterised by the social opportunity and reflective motivation components as they include the role of social influence as well as social and professional responsibilities. The authority time-geographic constraint is characterised by the physical opportunity and automatic motivation component.

Table 4: Links between the TDF domains and the COM-B model as found in Michie et al. (2014)

COM-B components	TDF Domain	Domain definition	Theoretical constructs represented within each domain
Physical capability	Skills	An ability or proficiency acquired through practice	Skills; skills development; competence; ability; interpersonal skills; practice; skill assessment
Psychological capability	Knowledge	An awareness of the existence of something	Knowledge (including knowledge of condition/scientific rationale); procedural knowledge; knowledge of task environment
	Cognitive and interpersonal skills	An ability or proficiency acquired through practice	Skills; skills development; competence; ability; interpersonal skills; practice; skill assessment

COM-B components	TDF Domain	Domain definition	Theoretical constructs represented within each domain
	Memory, attention, and decision processes	The ability to retain information, focus selectively on aspects of the environment and choose between two or more alternatives.	Memory; attention; attention control; decision making; cognitive overload/tiredness
	Behavioural regulation	Anything aimed at managing or changing objectively observed or measured actions	Self-monitoring; breaking habit; action planning
Physical opportunity	Environmental context and resources	Any circumstance of a person's situation or environment that discourages or encourages the development of skills and abilities, independence, social competence, and adaptive behaviour	Environmental stressors; resources/material resources; organisational culture/climate; salient events/critical incidents; person x environment interaction; barriers and facilitators
Social opportunity	Social influences	Those interpersonal processes that can cause individuals to change their thoughts, feelings, or behaviours	Social pressure; social norms; group conformity; group norms; social support;
Reflective motivation	Social/professional role and identity	A coherent set of behaviours and displayed personal qualities of an individual in a social or work setting	Professional identity; professional role; social identity; identity; professional boundaries; professional confidence; group identity; leadership; organisational commitment

COM-B components	TDF Domain	Domain definition	Theoretical constructs represented within each domain
	Beliefs about capabilities	Acceptance of the truth, reality or validity about an ability, talent, or facility that a person can put to constructive use	Self-confidence; perceived competence; self-efficacy; perceived behavioural control; beliefs; self-esteem; empowerment; professional confidence
	Optimism	The confidence that things will happen for the best or that desired goals will be attained	Optimism; pessimism; unrealistic optimism; identity
	Beliefs about consequences	Acceptance of the truth, reality, or validity about outcomes of a behaviour in a given situation	Beliefs; outcome expectancies; characteristics of outcome expectancies; anticipated regret; consequents
	Intentions	A conscious decision to perform a behaviour or a resolve to act in a certain way	Stability of intentions; stages of change model; transtheoretical model and stages of change
	Goals	Mental representations of outcomes or end states that an individual wants to achieve	Goals (distal/proximal); goal priority; goal/target setting; goals (autonomous/controlled); action planning; implementation intention
Automatic motivation	Reinforcement	Increasing the probability of a response by arranging a dependent relationship, or contingency, between the response and a given stimulus	Rewards (proximal/distal, valued/not valued, probable/improbable); incentives; punishment; consequents; reinforcement; contingencies; sanctions

COM-B components	TDF Domain	Domain definition	Theoretical constructs represented within each domain
	Emotion	A complex reaction pattern, involving experiential, behavioural and physiological elements, by which the individual attempts to deal with a personally significant matter or event	Fear; anxiety; affect; stress; depression; positive/negative affect; burn-out

The COM-B model is relatively new and studies using the COM-B model in the transport literature are scarce. So far, only the following three published transport-related studies were found specifically referencing the COM-B model. The first study is by Ahern et al. (2017) who used the COM-B model to develop a semi-structured topic guide to understand barriers to active school travel among parents of primary school children. The authors made use of the TDF domains as this allows researchers to build up an understanding of behaviours in context. The results show the main barrier for active school travel was distance with time (environmental context domain), and concern for safety (beliefs about consequences and skills domains) (Ahern et al., 2017). The second study references the COM-B model in relation to sustainable transport (Wells and Pangbourne, 2015). The authors use the COM-B model to understand the formation of habit behaviour recognising motivation as a critical factor for lasting behaviour change. The third study by Arnott et al. (2014) is a systematic review of the efficacy of behavioural interventions to reduce car use for journeys made by adults. The interventions were categorised in terms of whether they address capability, opportunity, and motivation. In summary, only the study by Ahern et al. (2017) used the COM-B model to explain travel behaviour.

Although the COM-B model has not been extensively used in the transport literature, it has been used extensively in the health sector. The benefit of employing the COM-B model over a single theory is that several distinct explanatory components are outlined. Thus, Lambe et al. (2020) highlighted the benefit of the COM-B model over other more established theories because of its simple design yet comprehensive model summarising all potential influences on behaviour.

2.2 Young adults' travel behaviour

The body of research into young adults' travel behaviour is still limited but has been gaining increasing attention in recent years. Several studies have emphasised how university students are not well represented in general population behavioural surveys (Wang et al., 2012, Hafezi et al., 2018). The importance in representing students in travel behaviour studies is verified by Jamal and Newbold (2020). The authors found factors influencing each generation's travel characteristics were either different or differ in their nature of influence. This calls for more studies on the travel intentions of young adults to predict future travel behaviour especially since they represent the coming generation of the workforce (Lin et al., 2019).

Compared to older adults, young adults are more likely to delay obtaining a driver's licence, make fewer trips, own fewer cars and be open to use different transport modes (Delbosc et al, 2019, Jamal and Newbold, 2020, Delbosc and Nakanishi, 2017, Puhe and Schippl, 2014). Studies have explained this behavioural shift with improvements in and promotion of alternative transport (Kuhnimhof et al., 2012a) and the increase in costs of travelling by car when compared to public transport (Herrenkind et al., 2019). Moreover, Delbosc and Currie (2013) provide a synthesis of evidence for the causes of decline in driving licences among young adults across 14 countries, including the UK. Six potential causal factors were identified: (1) life stage; (2) affordability; (3) location and transport; (4) driver licencing regulations; (5) attitudes; and (6) e-communication. Similarly, Chatterjee et al. (2018) reported the decline in car use among young adults in the UK was attributed to the socio-economic and living situations as compared to their parents' generation. These include increased higher education participation, rise of lower paid and less secure jobs, decline in disposable income, decline in homeownership and re-urbanisation. However, Delbosc and Currie (2013) found changes in life stage and household living arrangements to demonstrate the clearest and most consistent impact on changes in young adults driving licences.

The importance of life stages or events lies in their ability to act as windows of opportunity for travel behaviour change (Larouche et al., 2020, Zarabi et al., 2019, Thomas et al., 2016). This is explained by the habit discontinuity hypothesis where previous habits become weakened and new habits can be formed (Verplanken et al., 2008, Jones and Ogilvie, 2012). Van der Waerden et al. (2003) identified 90 key events and critical incidents with the potential to make participants switch to another transport mode. A list of 16 key events and critical incidents were short listed with the most mentioned events being relocation, starting a first job, change in employment, getting a driving licence and getting a car. Klöckner (2004) also listed the life events influencing a change in travel mode with the most identified events being moving to a new town, starting studies or an apprenticeship, acquiring a driving licence, moving to secondary school, buying a car, and starting employment. Larouche et al. (2020) examined the effects of seven events on travel behaviours concluding that major life events were indeed windows of opportunity for travel behaviour change, however the direction of changes in travel behaviour was highly variable and dependent on a wide range of contextual factors. Therefore, researchers are questioning the continuation of the decline in driving licence and car ownership interest among young adults as they get older and transition into the life stages of starting employment, relocating, or starting a family (Delbosc and Nakanishi, 2017, Chatterjee et al., 2018).

Finishing university and starting a new job are key events, however the transition from university education to the workforce is not well researched (Müggenburg et al., 2015). Harms and Lanzendorf (2007) studied 580 university graduates at Leipzig University who left university between one to three years before the survey. The authors show graduating from university and the transition to working life does not happen instantly but over several years. A person's mobility needs, opportunities and/or abilities can change with the result of a life event (Harms and Lanzendorf, 2007). Thus, the authors found time constraints and a rise in income, the importance of being well dressed and the need of a car for the new job were reported as factors influencing university graduates' mode choice. Harms and Lanzendorf (2007) concluded how the most decisive changes in mobility behaviour occurred when the first well-paid full-time job started. Similarly, Busch-Geertsema and Lanzendorf (2017) examined the mode use of students before and after starting their employment using the TPB and the ROA approach, the concept of habits and key events. The study shows students transitioning into working life changed their commuting mode more often than those who remained as students. Job starters were found to switch their mode of travel away from public transport and towards the car. These studies highlight the importance of the university – to – work transition as a window of opportunity for behavioural change.

Entry into the labour market is associated with an increase in car use and a decline in use of sustainable transport (Larouche et al., 2020). Delbosc et al. (2019) focused on the role of the transport system and local transport facilities as shaping young adults' travel behaviour. The authors conclude how cities need to focus on providing public transport systems that support the travel needs of young adults as they age and move through life stages. Studies have shown how a good public transport system linked to employment sites would suppress the growth in car ownership (Clark et al., 2015). Therefore, facilitating access by public transport to key destinations such as higher education and employment sites for young people can potentially reduce car ownership and use over the longer term (Clark et al., 2015). Moreover, providing job starters with a discounted travel ticket similar to the one offered to students can entice job starters into commuting by public transport (Busch-Geertsema and Lanzendorf, 2017). Nevertheless, Delbosc et al. (2019) call for more studies on the impact of travel systems on young adult travel behaviour.

2.3 MaaS as a travel option

An innovative transportation strategy that enables users to gain short-term access to transportation modes on an "as-needed" basis is shared mobility (Shaheen, 2016). The latter is a subset of the larger sharing economy and includes various forms of carsharing, bikesharing, ridesharing, on-demand ride services and micro mobility services. Car and bike sharing offer several advantages over private vehicle ownership and use. The impacts of shared mobility have been documented in cities worldwide – cost savings and convenience, reduced vehicle miles travelled and personal vehicle ownership. However, the uptake of car and bike sharing services in the UK is considered to be low and linked to specific demographic profiles. Münzel et al. (2020) analysed the supply of shared cars across 177 cities in five Western European countries including the UK and found carsharing is popular in cities with a high educational level or university presence. Car sharing remains a marginal activity in the UK, used by only a small proportion of the population mainly young professionals without children and those living in central parts of cities (Rodrigues et al., 2016, Akyelken et al., 2018). In terms of bike sharing, the UK has a relatively low level of general cycling compared to cycling countries such as the Netherlands (Fishman, 2016). Hence, two of the strongest and most recognisable international bike sharing operators, Mobike in Manchester and Ofo in London, had to withdraw their businesses because of huge financial or operational failures (Nikitas, 2019). Nevertheless, bike sharing has the potential to impact public transport and other modes, serving as an effective and efficient first- and last-mile connection with no energy usage (Shaheen, 2016). Overall, these new mobility services including others such as ridesharing, micro mobility and on-demand ride services, in combination with traditional public transport, could provide a viable alternative to private vehicle use.

Several studies have shown how shared services can lower car use and ownership (König et al., 2018, Caulfield and Kehoe, 2021, Blumenberg et al., 2021). Such services were found to complement existing services solving the first and last mile problem such as the journey to or from a public transport station (König et al., 2018, Zhu et al., 2020, Wilson and Mason, 2020). However, Wilson and Mason (2020) found the use of such services to depend on whether the higher cost justified the increased convenience or timeliness compared to the private car. In fact, Caulfield and Kehoe (2021) found the main motivation of their participants to use a carsharing scheme was the lower cost compared to car ownership.

The travel purpose for using such services was observed for long distance trips and trips for purchasing groceries and larger items, which are trips often cited as some of the main reasons for car ownership (Caulfield and Kehoe, 2021). With regards to the influence of household car ownership on using shared mobility services, Blumenberg et al. (2021) found high income zero-vehicle households to be positively associated with the use of ridesharing and carsharing services. On the other hand, low-income households were found to have significant barriers to using rideshare services. Such barriers included cost, lack of credit cards and smartphone access (Blumenberg et al., 2021).

Urban mobility options have increased in recent years, and access to these options is being assisted by smartphone and mobile 'apps' that aggregate and optimize these mobility services. Modern ICT and new transport systems may play a driving role in the changing behaviour of young adults (Hunecke et al., 2020). Smartphone applications and travel platforms are rapidly becoming effective tools in the transport sector. They provide real time information, public transport arrival and departure times, route planning and navigational functions and allow citizens to choose sustainable transport modes (Di Dio et al., 2018, Brazil and Caulfield, 2013). The popularity of mobility sharing services is growing rapidly around the world as car, bike, scooter sharing services are moving towards the MaaS model showing potential in these services to change how we think about mobility (Caulfield and Kehoe, 2021, Wilson and Mason, 2020).

MaaS is an emerging and evolving phenomenon which is a technology-driven innovation. MaaS is an app-based scheduling, booking and payment platform for multiple transport modes on a per trip or subscription basis. Using a single application or online interface, a MaaS user can buy mobility services as pay-as-you-go or they can buy mobility packages based on their travel needs (Kamargianni et al., 2016). The service acts as a one-stop shop where different transport modes are combined into a subscription plan that can be accessed from a smartphone application. The transport options offered within MaaS are not limited to public transport but aim to include taxis, carsharing, ridesharing and bike sharing, as well as other forms of mobility services to allow for multimodal mobility in which various trip options are available for the user to make a personal choice based on their travel needs (Hoerler et al., 2020, Hensher et al., 2021). Thus, MaaS is based on three main components: (1) ticket and payment integration; (2) mobility package; and (3) ICT integration (Kamargianni et al., 2016).

The use of smartphone technology is synonymous with the younger generation however not all young adults own and use technologies to the same extent (Regalado and Smale, 2014). Nevertheless, young adults are found to engage most strongly in the sharing economy (Chatterjee et al., 2018) continuing to contribute to the declining trend in car ownership (Bayart et al., 2020). The decision-making power that a user has on these types of services is explained by Mas-Machuca et al. (2021) whereby ridesharing platforms allow customers to request a particular car model or fuel type and can customise their trip. Thus, Hoerler and Hoppe (2019) believe these tailor-made mobility services have the potential to meet customer needs and increase the acceptance and use of such services.

The potential early adopters of MaaS are considered to be young public transport users and flexible travellers making commuting and business trips (Jittrapirom et al., 2020) and research has repeatedly shown how young adults, compared to older adults, are more open to use different transport modes and engage in multimodal travel behaviour (Kuhnimhof et al., 2012b, Nobis, 2007). Hunecke et al. (2020) argue how young adults are transitioning towards a multimodal society due to their altered life situations along with changes in their psychographic (activities, interests, and opinions) characteristics with respect to cars and other modes. Thus, the decline in car ownership interest, multimodal behaviour and the use of public transport and shared mobility services positions MaaS as a potential tool to increase sustainable transport choices among young adults.

A number of studies aiming to understand what could make MaaS appealing to the public cited the inclusion of a carbon calculator to inform users of the amount of carbon footprint their journey will have (Brazil and Caulfield, 2013, Büchs et al., 2018), financial incentives (Hensher et al., 2021), good quality public transport and shared mobility services (Hensher et al., 2021), matching the convenience and comfort of the private vehicle (Biehl and Stathopoulos, 2020) and different subscription plans to address different mobility lifestyles (Marsden et al., 2020, Arias-Molinares and García-Palomares, 2020, Hesselgren et al., 2020, Caiati et al., 2020a). Another factor which can influence MaaS adoption was being familiar with existing shared mobility services. Hoerler et al. (2020) found public transport and carsharing users were more open to using MaaS compared to those who travelled by private car. Travel purpose was also found to influence participants openness to use MaaS with participants claiming they would use MaaS for leisure activities unless it was flexible and fast for them to use it for commuting. Hence, Hoerler et al. (2020) concluded how the development of MaaS services needs to focus on three commuting needs: spontaneity, lower costs, and shorter transfer times.

Barriers to the uptake of MaaS were reported in Butler et al. (2020) following a systematic literature review. Such barriers were the lack of appeal from older generations, public transport users and private vehicle users, the attractiveness of the digital platform and user willingness to pay. Similarly, Araghia et al. (2020) studied the relevant drivers and barriers of MaaS and new mobility services in the highly regulated European market. The authors found how the uncertainty in the demand was due to the lack of knowledge and the resistance to new alternative modes as well as a digital divide. Jain et al. (2020) believe the benefit of having all transport modes in one digital platform alleviates the stress associated with the planning required to live car-free. Ultimately, the market penetration of such technologies is influenced both by the attitudes of users and the regulatory environment (Emberger et al., 2020). Paddeu et al. (2020) explained how social acceptance becomes a key factor which affects the time between the introduction of a new concept and its actual implementation. Therefore, an innovative solution needs public acceptance to be successful in the long term (Paddeu et al., 2020).

Discrete choice experiments evaluating MaaS uptake

For the purposes of this thesis a review of the DCEs evaluating the potential of MaaS adoption was conducted. Proponents of MaaS believe that it has the potential to improve the shared transport system by causing a shift in modality where people become less dependent on their personal cars. In addition, MaaS can create benefits in relation to urban congestion, air pollution and health. Therefore, determining the factors influencing potential MaaS adoption would help researchers, transport operators and policy makers to understand how the transition towards shared mobility and public transport can be accelerated.

Considering MaaS is a novel concept, researchers can predict the market demand for innovative and shared ride services using models from DCEs. This is done by quantifying the impacts of socio-economic characteristics and modal attributes such as travel cost and time, on a traveller's mode of choice (Sfeir et al., 2020). A handful of quantitative studies have used DCEs to predict the potential demand for MaaS concentrating on eliciting respondents' preference towards a type of MaaS subscription (Caiati et al., 2020b, Matyas and Kamargianni 2017, Ho et al., 2020). Such studies offered insights into the community's willingness to pay for mobility packages, helping to forecast demand, estimate mode shares and inform the design of MaaS packages (Wong et al., 2018). The attribute of cost for each MaaS plan was defined by the monthly subscription price. Similar to other studies, the MaaS studies found individuals to prefer inexpensive MaaS plans (Caiati et al., 2020b, Matyas and Kamargianni, 2019). The travel time attribute was featured differently in the choice experiments. In the DCEs, the travel time attribute in the MaaS bundles was defined either as limited or unlimited trips for each transport mode. Respondents were found to show preferences for MaaS bundles with a flat rate option (i.e., unlimited rides, in Caiati et al. 2020b). Meanwhile, qualitative studies provided a deeper understanding of the stakeholders and end users motives, expectations, perceptions, and concerns on MaaS (Alyavina et al., 2020, Polydoropoulou et al., 2020). Qualitative studies use a thematic analysis approach to identify, organise and offer insights into patterns of themes across several items of qualitative data (Alyavina et al., 2020). Alyavina et al. (2020) found five core themes to be critical determinants underpinning MaaS acceptance and success: car dependence; trust; human element externalities; value; and cost. In another study, Polydoropoulou et al. (2020) used a qualitative cluster analysis to reveal the potential commonalities and differences in the stakeholders' opinions.

The impact of socio-economic and individual characteristics on potential MaaS adoption included age, gender, number of children in the household, number of cars available in the household and education. Young people were more likely to subscribe to MaaS (Ho et al., 2018, Caiati et al., 2020b) in line with the prediction of early MaaS adopters (Jittrapirom et al.,2017). In terms of educational level and employment status, Caiati et al. (2020b) found students, people in employment and retired people were more likely to join a MaaS scheme. However, those with a middle level of education were more likely to subscribe to MaaS than those with a higher education level. In Caiati et al. (2020b) the number of cars in a household was found to impact potential subscription. Individuals having access to more than one car in a household were less likely to subscribe compared to those with just one car available in the household. This is contrary to a study by Ho et al. (2018) which did not find the number of household cars to impact MaaS subscription propensity. Households with two or more children were significantly less likely to subscribe to MaaS in comparison with households having up to one child (Ho et al., 2018). Whereas Caiati et al. (2020b) reported single or couples with children were found to more likely subscribe to MaaS, however the number of children in the household was not specified.

The studies previously mentioned are set in specific locations including London, UK (Matyas and Kamargianni, 2019), Sydney, Australia (Ho et al., 2018), Tyneside, UK (Ho et al., 2020) and the Netherlands (Caiati et al., 2020b). The appeal of MaaS can differ from one city to another as found by Ho et al. (2020). The authors found non-car users in Tyneside UK expressed the highest tendency to subscribe to a MaaS plan unlike non-car users in Sydney. This was explained by the ticket system available in both cities. Sydney had an integrated ticketing system available, whereas transport services in Tyneside were deregulated. Therefore, the added value of a MaaS platform that links multiple public transport services and offers an integrated mobility solution was found more valuable for users in Tyneside.

An individual holding a carsharing membership was found to be more likely to subscribe to MaaS (Caiati et al., 2020). However, Ho et al. (2018) did not find carsharing membership to impact MaaS subscription propensity. Other mobility tools positively affecting the subscription decision were the possession of a driving licence and smartphone ownership. Caiati et al. (2020b) argue people with a driving licence get to benefit from the full service of MaaS because they would be allowed to use carsharing and car rental services. People less likely to subscribe to MaaS were travellers who walk, bike, or drive. Whereas people who were car passengers and public transport users were more willing to subscribe to MaaS (Caiati et al., 2020b). From their studies, Ho et al. (2018, 2020) found participants who used taxis or Uber regularly and at a minimum of once per week, found a MaaS plan to be very attractive. However, in a study by Matyas and Kamargianni (2019), the inclusion of shared transport modes such as bike sharing, carsharing and taxis were found to lower the attractiveness of MaaS. Thus, all else being equal, individuals were less likely to subscribe to a MaaS plan and preferred to stick to their status quo (Ho et al., 2018, Caiati et al., 2020). Nevertheless, the inclusion of public transport in MaaS plans is essential for potential adoption as shown by Matyas and Kamargianni (2019) who found existing public transport options to have positive coefficients compared to other available transport modes within a MaaS plan.

Table 5: Studies using stated choice experiments to predict the potential adoption of MaaS

Authors	Location	MaaS Bundles or Plans	Attributes	Transport Modes included	Preferred MaaS plans	Determinants of MaaS subscription	Opt out option
Caiati et al (2020b)	Netherlands	Respondents choose up to 4 transport modes defined by varying attribute levels to configure their subscription	• Public transport • E-bike sharing • E-carsharing • Taxi • Car rental • Ridesharing • On-demand bus • Subscription price for a bundle on a monthly basis • Time commitment • Data required for the registration	• Public transport (bus, metro, and tram) • E-bike sharing • E-carsharing • Taxi • Car rental • Ride sharing • On demand bus	Public transport is the most preferred option. Taxi and car rental are the least preferred transport modes. Utility of choosing public transport increases when it is offered at a flat rate (i.e., unlimited rides). Public transport is preferred for people older than 50 years. Younger people (25-35 years) are less	Probability of subscribing to the service decreases at an increasing rate with increasing price. Long-term subscriptions (12 months) are preferred over short-term plans (1-3 months). The app access to GPS increases the utility of MaaS subscription. Positive reviews of the service from the general public significantly and positively influence the subscription intention. Females more likely than males to subscribe to MaaS (small coefficient but significant). Younger people (18-35 years of age) are more positively inclined to subscribe.	Not included

Authors	Location	MaaS Bundles or Plans	Attributes	Transport Modes included	Preferred MaaS plans	Determinants of MaaS subscription	Opt out option
			• Service reviews from the general public • Share among relatives • Share among friends • Share among colleagues		likely to include public transport in their bundle.	Workers with a middle level of education and students are more likely to subscribe. People with a monthly income between €1251 and €1875 and those with a very high income (>€3125) more likely to subscribe. Access to only one car in the household are more likely to subscribe. Possession of driving licence, smartphone ownership and carsharing membership positively affect the subscription decision. People travelling by car as a passenger or by public transport or train are more willing to subscribe to MaaS.	

Authors	Location	MaaS Bundles or Plans	Attributes	Transport Modes included	Preferred MaaS plans	Determinants of MaaS subscription	Opt out option
Matyas and Kamargianni (2017, 2019)	Greater London	• Plan A • Plan B • Plan C • Plan Customised	• Subscription fee • Transport modes included in each plan • Offered travel allowances for each transport mode • Availability of additional features	• Public Transport (bus, tube, overground, Docklands Light Rail, tram, rail, and riverboat) • Bike sharing • Carsharing • Taxi	Preference for public transport options and less preference for bike sharing, carsharing and taxi.	People owning travel cards prefer a MaaS plan that includes unlimited access to public transport.	Not included
Ho et al (2018)	Sydney, Australia	• Two pre-defined MaaS plans customised on participants travel records	• Fortnight subscription fee • Volume of access for each transport mode	• Public transport • Car share • Taxi • UberPooL	Utility of choosing public transport increases when it is offered at a flat rate (i.e., unlimited rides).	Age and number of children in the household affect the likelihood of MaaS adoption. People aged 51 and older are less likely to subscribe to MaaS. Households with up to one child are	

Authors	Location	MaaS Bundles or Plans	Attributes	Transport Modes included	Preferred MaaS plans	Determinants of MaaS subscription	Opt out option
		• Pay-as-you go plan • Status quo	• Possibility to roll-over unused credit			more likely to subscribe compared to those with two or more children.	
Ho et al (2020)	Tyneside, United Kingdom	• Two pre-defined MaaS plans customised on participants' travel records • Pay-as-you go plan • Status quo	• Monthly subscription fee • Volume of access for each transport mode • Possibility to roll-over unused credit	• Taxi • Bike share • Car share • Public transport (bus, metro, train, ferry)	Pay-as-you-go option increases MaaS uptake.	MaaS shares decrease as the frequency of car use increases. Car non-users express the highest tendency to subscribe to MaaS plans Infrequent car users are most likely to pay as they go Frequent public transport users are more likely to buy into MaaS offerings Households with fewer cars than drivers are more likely to subscribe as regular users of MaaS than as a pay-as-you-go user.	Included in the form of a status quo option which when chosen the respondents is asked for a reason for not taking up MaaS offers.

2.4 Summary and research aims

The literature review in this chapter first focused on how studies have used sociodemographic characteristics, travel behaviour and travel mode attributes to explain mode choice. The TPB is a well-established theory for predicting modal choice and travel behaviour based on an individual's attitudes, subjective norms and PBC. Studies have shown how the TPB can be used to predict the use of public transport however the TPB is yet to be used to examine travel behaviour in the context of MaaS where public transport and shared mobility services such as carsharing, ridesharing, and bike sharing are used for everyday activities. Participants' modal choice was found to be influenced by personal and mobility preferences. Given the MaaS concept is relatively new there is a need to study consumers preference for MaaS to predict its uptake. Most studies have focused on finding the most appealing subscription plan for potential users using DCEs. DCEs allow researchers to predict the market demand of an innovative service which is not yet available on the market. The use of DCEs to explore consumers appeal for MaaS in the current market of subscription travel services has not yet been explored. Using DCEs can also identify travellers' sensitivities to travel mode attributes (fare, travel time and walking distance) which have been found to affect participants choice of using shared mobility services and public transport (König et al., 2018, Chowdhury and Ceder, 2016).

Traditional studies on mode choices typically treat travellers decision-making processes as planned behaviour (de Luca and Mascia, 2021). However, travellers' choices are complex, meaning other underlying factors related to their personal and motivational influences can impact mode choice. Such factors would include the life situation of an individual, their social and professional role and the quality conditions of public transport infrastructure. Researchers have explored these underlying factors using the ROA model and Hägerstrand's time-geographic constraints on modal choice. Elements from both the ROA model and Hägerstrand's time-geographic constraints can be found in the COM-B model. The COM-B model addresses the complex interplay between individual, social, and environmental factors influencing travel behaviour and mode choice. The model provides a simple framework for understanding behaviour, in which capability, opportunity and motivation are conceptualised as three essential conditions in which the behaviour occurs (Michie et al., 2011). To help unpack the COM-B model further and allow deeper exploration for understanding the behaviour (Cane et al., 2012), the TDF can be used which synthesises the overlapping behaviour theories. The COM-B model and the TDF have been extensively used to identify factors influencing a range of behaviours within the health literature (Tavender et al., 2014, Boscart et al., 2012, Duncan et al., 2012), however it remains scarce in the transport literature. Hence, The COM-B model and TDF have not yet been used to explore the underlying factors to a traveller's choice of transport mode.

The second part of this chapter dealt with the shift in travel behaviour reported for young adults. A decline in car ownership and driving licences has been reported for young adults who are engaging more with shared mobility services and public transport use. Reasons for this behaviour are attributed to young adults living in urban areas, having less disposable income, and staying longer in higher education. However, the continuation of the decreasing car ownership and driving licence trend is less certain as young adults move through other life stages. Young adults' life stages of starting studies and starting employment have been found to influence travel mode choice. However, entry into the workforce has been linked to the purchase of a car. Yet studies have marginally investigated the transition from university education to the workforce on travel choice. During this transition young adults' mobility needs, opportunities and abilities change leading to the decline in public transport use and shifting more towards the private car.

Building on this literature review, the literature shows a gap in studying young adults travel choice as they transition from university education to the workforce. The literature identifies young adults as early adopters of shared mobility and open to using different modes of transport. Considering how MaaS combines different transport modes including the option of driving via carsharing, MaaS can act as a tool for young adults to make sustainable travel choices as they transition into the workforce. Hence, the appeal of MaaS for young adults needs to be studied to predict the usefulness of MaaS during this life transition, and its effectiveness in reducing interest in car ownership. Therefore, this research aims to identify the determinants of multimodal behaviour and intention of using public transport and shared mobility services, explore the travel attributes influencing the adoption of MaaS in the current market, and investigate the underlying factors that influence young adults' mobility decisions as they transition from university education to the workforce.

Chapter 3 Research Methodology and Methods

As discussed in Chapter 2, an individual's mode choice is influenced by several factors stemming from psychology, economics, and behaviour. The purpose of this research was to explore the influence of mode choice among young adults within the context of MaaS. The aim was to evaluate the potential of MaaS as a tool for sustainable travel choices among young adults. This chapter presents the research philosophy, approach, design, and procedures to answer the research questions.

3.1 Research philosophy and approach

The research methodology is a systematic way to solve the research problem where various steps are adopted by a researcher in carrying out the research project (Leedy and Ormrod, 2001). The concept of the 'research onion' by Saunders et al. (2019) (Figure 3) clearly explains the different decisions a researcher takes when designing their research project. The approach to use the research onion framework is to go from the outer layer to the inner layer and each layer represents a key phase of the research process (Saunders et al., 2019).

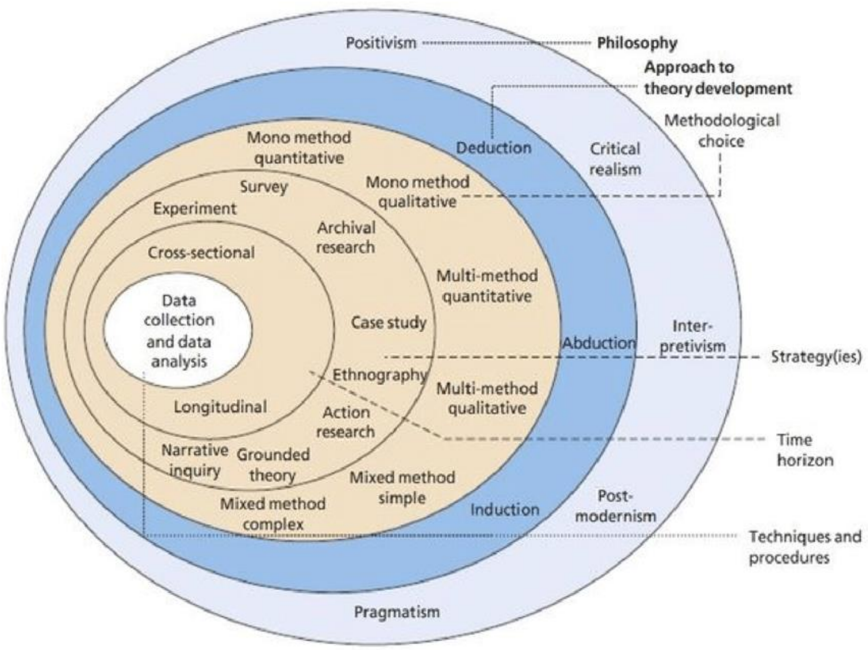


Figure 3: The Research Onion (Saunders et al., 2019)

The research philosophy sits in the outermost layer which is a system of beliefs and assumptions about the development of knowledge (Saunders et al., 2019). Before discussing individual research philosophies, Saunders et al. (2019) presents three types of research assumptions to distinguish research philosophies: ontology, epistemology, and axiology. At this stage, the assumptions and views about how research should be conducted influences the research process (Bryman, 2016). Ontology refers to the assumptions about the nature of reality and axiology refers to the role of values and ethics within the research process (Saunders et al., 2019). For the purpose of this research an epistemological approach was taken as this follows the scientific approach whereby a hypothesis is formulated and then tested using measurement techniques (Bryman, 2016). The two main philosophical frameworks linked to epistemology are positivism and interpretivism (Bryman, 2016). Positivism assumes that knowledge is independent of the subject being studied. This means positivism provides a sense of objectivity and is mainly based on quantitative statistical methods (Saunders et al., 2019). On the other hand, interpretivism claims that individual observers have their own perception and understanding of reality. This means interpretivism provides a sense of subjectivity where it focuses on creating new and richer understandings from the narratives, stories, perceptions, and interpretations (Saunders et al., 2019).

This research follows an epistemological approach as the aim is to provide empirical evidence for MaaS as a tool that can help young adults make sustainable transport choices. However, the aim does not fit into one of these two philosophical streams. Some research questions lean towards a positivist philosophy because they aim to quantitatively measure mode choice. Other research questions favour a more interpretivist philosophy as they aim to understand mode choice using participants personal experiences, perceptions, and interpretations of MaaS in relation to their travel needs. Therefore, a pragmatic research philosophy approach was chosen whereby a research problem was identified and a range of methods from the literature were identified to answer the research questions (Saunders et al., 2019). The research problem identified for this thesis was the unsuccessful launch of MaaS in the West Midlands (further details are provided in Section 3.3).

After choosing the appropriate research philosophy, the research onion suggests that an appropriate research approach must be picked. Identifying the research approach would inform the decisions taken in terms of data collection and analysis of the study. Saunders et al. (2019) explain there are three main types of research approaches: deductive, inductive, and abductive. The difference between the three approaches is the relevance of the hypothesis to the study. The deductive approach is based on the literature review where a specific hypothesis is created which is then tested using existing theories. On the contrary, an inductive approach starts with observations that the researcher uses to generate a new theory. A combination of the deductive and inductive approach is the abductive. The latter starts with data collection to explore a phenomenon to generate a new theory, which is then subsequently tested through additional data collection (Saunders et al., 2019).

This thesis generally follows a deductive approach. Following a review of the literature, hypotheses were created, and appropriate theories and methods were identified. Despite MaaS being an emerging field, research on travel mode choice is extensive and several theoretical and analytical frameworks have been used to predict mode choice. Therefore, to test the hypotheses generated from the literature review in Chapter 2, tried and tested methods appropriate for each research question were used. The next section presents the four inner layers of the research onion which form part of the research design.

3.2 Research design

The original aim was to study the characteristics of adopters and non-adopters of MaaS in the UK. Even though several MaaS trials and commercialised MaaS products were available in Europe and internationally, including in the UK, the unsuccessful launch of MaaS in the UK (see Section 3.3) required the author to adjust the aim of this thesis. Considering MaaS was still in its infancy and the literature available on MaaS was limited, the specific methods and theories chosen stemmed from the literature review on travel behaviour aiming to understand the shift from private car to public transport and more sustainable travel options. The first hurdle was the lack of a definition for MaaS which was required to define the target behaviour being asked of participants. This led to the creation of a definition using multiple research studies (Jittrapirom et al., 2017, Matyas and Kamargianni, 2019, Alyavina et al., 2020), while also taking into consideration the study location.

The first of the four inner layers of the research onion (Saunders et al., 2019) refer to the choice of method for conducting the research. Each research question was associated with an appropriate theory and method to collect the data. Both quantitative and qualitative methods were used and therefore this thesis follows a mixed methods design. According to Creswell (2014) this fits well with the pragmatist research philosophy. The use of both quantitative and qualitative methods provides a complete understanding of the research problem. When combined both methods overcome the limitations of each individual method (Creswell, 2014). For the purposes of this thesis the mixed methods approach used questionnaires and interviews. The final layer of the research onion consists of the data collection techniques and procedures used. This refers to the data collection methods, sampling population, data analysis and materials used.

Before explaining the population target for this thesis and data collection methods used for each research question, Table 6 presents the research questions, methods, and purpose. Figure 4 provides a flowchart showing how the different components within each section connect. Prior to implementing the three data collection methods, ethical approval was obtained from the General Research Ethics Committee, which was later known as the Science Research Ethics Committee, at the University of East Anglia. Ethical approval of the questionnaire was obtained on 1st February 2019 (GREC 18-1272). For the discrete choice experiment, ethical approval was obtained on 16th May 2019 (GREC 18-1403). Ethical approval for the interviews was obtained on 8th December 2020 (SCI-ENV/2021/R/52).

Table 6: Research questions, methods used, and purpose

Chapter	Research question	Method	Theoretical Framework Used	Purpose
4	**RQ1a**: What determines multimodal travel behaviour? **RQ1b:** Which psychological factors influence the use of public transport and shared mobility services?	Questionnaire	Theory of Planned Behaviour	To gain an insight into the travel behaviour patterns of individuals who have been identified as potential MaaS users. To gain an insight into the attitudes of individuals towards public transport and shared mobility services.
5	**RQ2**: What is the appeal of MaaS?	Discrete Choice Experiment	Random Utility Theory	To examine an individual's preference of transport mode given specific travel mode attributes.
6	**RQ3:** Which factors influence young	Interview	Capability, Opportunity, and	Identify the factors challenging and

Chapter	Research question	Method	Theoretical Framework Used	Purpose
	adults' mobility decisions as they transition from university education to the workforce?		Motivation Behaviour (COM-B) Model	facilitating participants use of public transport and shared mobility services. To gain an insight into which types of transport policies would impact the potential take up of MaaS.

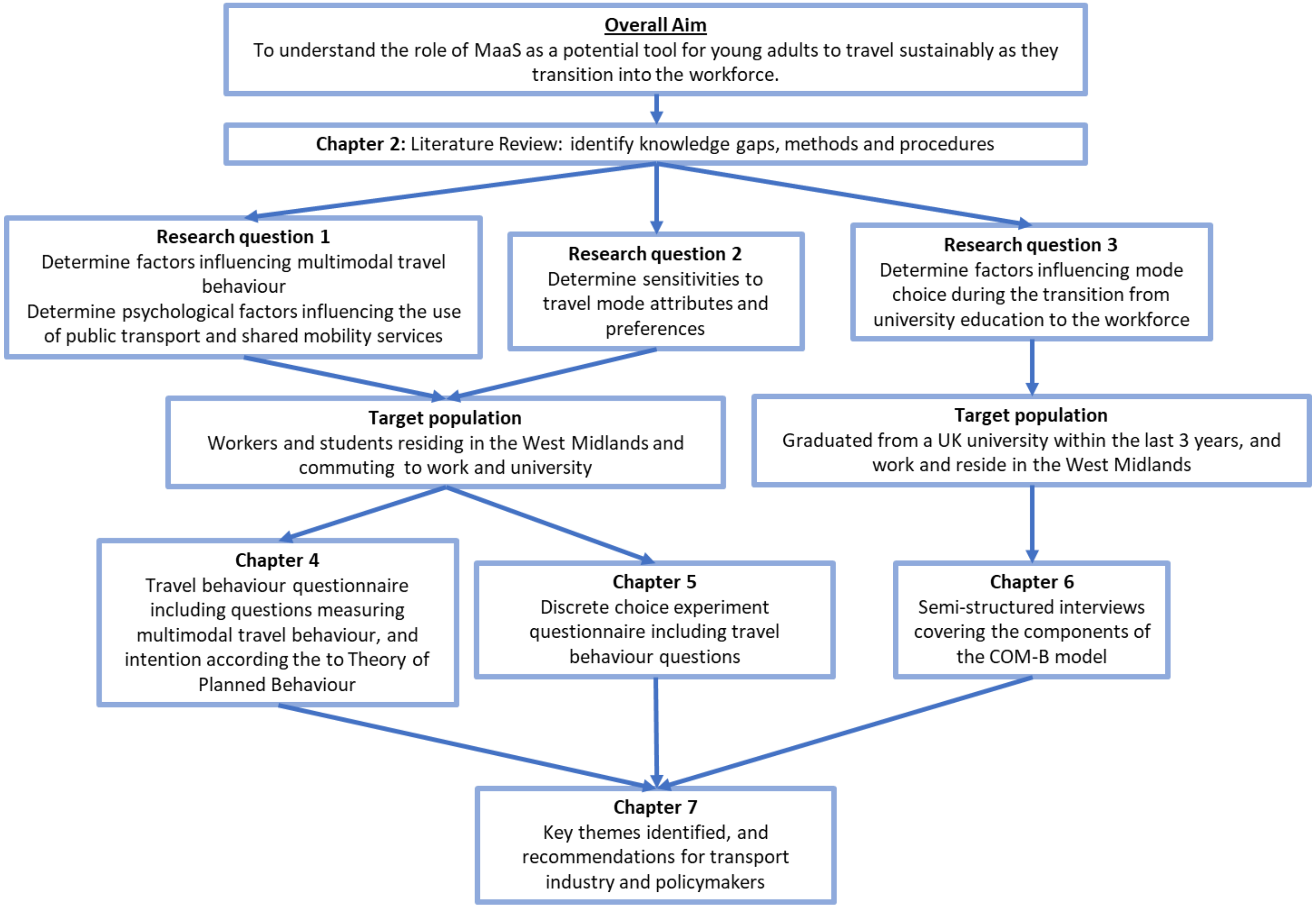


Figure 4: Research questions, methods used, purpose, and target population

3.2.1 Sampling strategy

Early adopters are the first users of the product whereas followers are potential users but not adopters (Jittrapirom et al., 2020). Experts believe MaaS would appeal to the younger generation and less so to older adults, because of its reliance on smartphone technology (Jittrapirom et al., 2020) with which the younger generation are assumed to be confident. However, the uncomplicated mobility patterns and limited purchasing power of young adults dampens the expectation for this cohort to be the early adopters of MaaS (Jittrapirom et al., 2020). In terms of trip purpose, commuting and business trips are expected to characterise early adopters of MaaS whereas education, shopping and leisure trips are expected to be the emphasis of later adopters or followers. In a study by Polydoropoulou et al. (2020) stakeholders in Greater Manchester identified the target end-users of MaaS to be young people and professionals. Thus, the target sample for this thesis were students and workers travelling for educational and working purposes as potential MaaS users or adopters.

Ho et al. (2020) emphasised the need for studies to examine groups with different commuting purposes when studying the demand for MaaS. They concluded that the insight gained from their MaaS demand study could be improved if separate models for different segments of the population were estimated (Ho et al., 2020). Therefore, this study identified workers and students as regular commuters who might find a MaaS subscription appealing for their travel needs. A number of studies have found students commute mode choice and travel patterns differed from those of the general population. It was hypothesised that students' sensitivities to modal attributes governing their mode choice decisions were distinctive (Danaf et al., 2014, Delmelle and Delmelle, 2012, Rodriguez and Joo, 2004, Zhou, 2012). For the purposes of this study, results for workers and students are analysed for their similarities and differences as both are considered commuters, but with different trip purposes and travel needs.

This thesis explores the novel concept of MaaS as a mobility tool. Given the exploratory purpose of the study, a non-probability sampling technique was employed (Saunders et al., 2019, Daniel, 2012). Considering the target population was specifically students and workers, a convenience sampling strategy was used. Universities and companies located in Birmingham and the West Midlands were considered as the gatekeepers for these samples. However, online social platforms such as Facebook and Twitter were also used to reach the target population and increase the number of participants for each study. Nevertheless, an element of snowball sampling was employed when recruiting participants for the qualitative study. The limitation of using non-probability sampling is that results cannot be generalised to the whole population. In addition, this sampling strategy can lead to self-selection bias where participants in the study tend to be biased towards the more cooperative participants and could be participating in the study out of personal interest in the subject. This was explained by Abou-Zeid and Fujii (2016) when it comes to interpreting the success of certain travel behaviour interventions in field experiments. They advise caution if participants are self-selected so may exhibit a stronger predisposition to use modes other than the car or to reduce their driving.

3.2.2 Data collection methods

Each research question sought to understand mode choice using different analytical methods as shown in Figure 4. All three research questions had a questionnaire either as their main data collection method (Chapter 4 and Chapter 5) or as a pre-interview questionnaire to select eligible participants for the study (Chapter 6). There are two categories of data collection, interviewer-administered questionnaires and self-completion questionnaires. Interviewer-administered questionnaires can be done face-to-face or by telephone but are timely and costly (Bryman, 2016). With a face-to-face method the researcher has an advantage in accessing respondents, maintaining control of the survey, and completing questionnaires speedily.

A self-completion approach using a web-based questionnaire was adopted. Specifically, for all data collection methods, the online survey tool Qualtrics was used as it provides mobile friendly features enabling participants to access the questionnaire using either a computer, tablet, or smartphone. The software also made it easy to distribute questionnaires online with quick access to the survey using a single link or QR code. The self-completion approach is often cheaper and allows respondents time to consider their answers. Thus, a self-completion approach using a web-based questionnaire was adopted because of the potential advantages over the interview-administered questionnaires. Such advantages included taking less time to administer the survey and reducing data entry errors because respondents entered the data themselves. One of the biggest drawbacks of using web-based questionnaires is that the questionnaire only reaches people who have access to the internet and a digital device. However, considering the target sample of students and professional workers this was less of a concern (Lewis-Beck, 2003).

The following sections provide an overview of the methodology used for each of the research questions. Further details on methods are included in subsequent empirical chapters.

Research question 1

The first research question is split into two research questions aiming to identify the factors that determine an individual's multimodal travel behaviour, and an individual's intention to use public transport and shared mobility services. Multimodal travel behaviour was explored to assess the potential use of MaaS given how experts believe public transport and flexible transport users are expected to be the early adopters of MaaS (Jittrapirom et al., 2020). Constraints impacting multimodal travel behaviour were examined using Hägerstrand's (1970) time-geographic constraints. The intention to use public transport and shared mobility services was examined using the TPB. The following paragraphs outline the method used for each research question.

Research question 1a: What determines multimodal travel behaviour?

Multimodal travel behaviour was measured using the one-week method by Molin et al. (2016), as most studies suggest that survey periods of one week tend to capture typical variability in everyday habitual travel behaviour (Block-Schachter 2009, Kuhnimhof et al 2006, Nobis 2007). Participants self-reported the frequency of the different transport modes they used for their everyday activities during a typical week measured on a five-point ordinal scale running from 'every day' to '1 to 3 days per month'.

The factors influencing multimodal travel behaviour were elicited from a study by Heinen and Chatterjee (2015). The authors characterised multimodal transport users in the UK using participants' travel mode and frequency of transport modes, and their sociodemographic and travel behaviour characteristics. The latter were inspired by the three time-geographic constraints of Hägerstrand (1970). These were capability, coupling and authority constraints and Heinen and Chatterjee (2015) provided examples for each constraint. Using these examples, several variables were chosen to predict multimodality for students and workers travelling in Birmingham. The capability constraints included mobility difficulties and the possession of a driving licence. Coupling constraints included the sociodemographic and economic variables of gender, age, employment status and public transport access close to the place of work. Commute distance was also measured given the economic freedom workers have to relocate in areas with less access to public transport services close to home (Heinen and Chatterjee, 2015). Variables representing authority constraints included housing tenure, access to public transport services close to home, car ownership and having a public transport subscription. For the purposes of this study, the type of public transport subscription analysed was the rail card. For both students and workers, the choice of analysing the role of a rail card subscription with multimodal travel behaviour, rather than using any other mobility transport subscription, was because of the dense railway network found in Birmingham conveniently located close to university campuses and the city centre. However, the Swift card and the Metro, Bus and Rail Pass subscription which allow for the use of more than one transport mode were not included in the analysis since these directly measure multimodality.

Given how the purpose of this thesis deals with a transport mobility service that is accessible through a smartphone application, the use of smartphone technology and purchase of mobile tickets were also used as predictors of multimodality. Thus, a significant relationship between the use of trip planners and purchase of mobile tickets with multimodality was expected since the literature claims the younger generation to be well versed in smartphone travel technology (Jittrapirom et al., 2017).

Following the identification of multimodal factors, several hypotheses were created:

- Hypothesis 1: Multimodal transport users have fewer capability constraints.
- Hypothesis 2: Multimodal transport users have fewer coupling constraints.
- Hypothesis 3: Multimodal transport users have fewer authority constraints.

Research question 1b: Which psychological factors influence the use of public transport and shared mobility services?

Given a typical MaaS subscription package is a collection of public transport and shared mobility services, the intention of participants to use such services was measured. Many of the studies on mode choice used behavioural models to understand and represent what consumers do and why (Axsen and Kurani, 2012) and to explain travel choices from a socio-psychological perspective (Busch-Geertsema and Lanzendorf, 2017). The TPB by Ajzen (1991) is one of the most well-established psychological models used to predict mode choice (Anable, 2005, Chowdhury and Ceder, 2016, Lanzini and Khan, 2017) where the intention to perform a behaviour can be predicted from attitudes, subjective norms and PBC. Based on the literature review in Chapter 2, the TPB has received good empirical support to explain mode choice in transport behaviour studies (Bamberg and Schmidt, 2001, Heath and Gifford, 2002). Although researchers have added other variables such as habit and pro-environmental attitude to improve the explanatory power of the TPB, the TPB with its original variables still offers a comprehensive and economical model to explain mobility behaviour with the limited resources of survey studies (Hunecke et al., 2007). Therefore, the theoretical framework of the

TPB was used to examine which of the three predictor variables are important for explaining the use of public transport and shared mobility services for everyday trips.

In terms of survey methodology, the TPB uses questionnaires as the main survey instrument to collect data. Thus, Ajzen (2006) and Francis et al. (2004) provide instructions on how to set up the questionnaire and examples of the questions to be used. Prior to setting up the questionnaire Ajzen (2006) and Francis et al. (2004) explain how the researcher needs to know its purpose to decide whether direct or indirect questions are to be used in the questionnaire. If the goal of the research is to predict intentions and behaviour, the direct measures of attitude, subjective norms and PBC are sufficient (Francis et al., 2004). The purpose of this study was to predict participants behavioural intention towards using public transport and shared mobility services. Thus, direct measures were used in constructing the questionnaire in accordance with established guidelines by Ajzen (2006) and Francis et al. (2004). Nevertheless, the questions were adapted to suit the target behaviour of this study.

The following hypotheses were created for the TPB variables:

- Hypothesis 4: Attitude has a significant and positive effect on behavioural intention towards the use of public transport and shared mobility services for everyday trips.
- Hypothesis 5: Subjective norms has a significant and positive effect on behavioural intention towards the use of public transport and shared mobility services for everyday trips.
- Hypothesis 6: Perceived behavioural control has a significant and positive effect on behavioural intention towards the use of public transport and shared mobility services for everyday trips.

Research question 2

The second research question aimed to examine the influence of travel mode attributes on mode choice. As explained in Chapter 2, research has shown how travel mode choice is not only influenced by psychological factors but also by travel mode attributes. The latter include travel time, which is split into waiting time, walking time and time spent inside the vehicle travelling, and cost which have been extensively used in DCEs to explain travel mode choice. The DCE is based on Random Utility Theory and proposes that individuals strive for utility maximisation when making a choice (Louviere et al., 2010). The DCE methodology is a quantitative research method that measures the strength of preference and trade-offs of participants towards different transport alternatives. The alternatives are each described by a set of attributes, which can then influence participants' choice (Vass et al., 2017, Schubert et al., 2020).

As discussed in Chapter 2, researchers can predict the market demand for innovative and shared ride services using models from DCEs, by quantifying the impacts of socio-economic characteristics and modal attributes such as travel cost and time, on a traveller's mode of choice (Sfeir et al., 2020). The attributes of cost, and travel time segregated into in-vehicle time, waiting time and walking time, were chosen following a literature review. Therefore, a DCE using a stated preference technique was used to examine which travel mode attributes would influence participants' preference for MaaS.

The following hypothesis was created for the DCE:

- Hypothesis 7: Cost has a negative effect and speed a positive effect on transport mode choice.

Research question 3

The purpose of the third research question was to capture graduate employees travel decisions as they transitioned from university education to the workforce. To better appreciate the context in which travel choices were made a qualitative approach was chosen (Kurniawan et al., 2018). The use of qualitative interviews, in conjunction with structured questionnaires, allow for the exploration of ideas and thoughts that would otherwise be missed when using survey instruments such as questionnaires, which frame the questions and limit the range of answers to those questions (Clifton and Handy, 2003). Therefore, using qualitative methods with quantitative approaches strengthen the understanding of the behaviour under study (Clifton and Handy, 2003, Michie et al., 2014). This choice diverges from much of the research that seeks to explain travel behaviour and mobility decisions which is dominated by quantitative research methods.

Qualitative methodology is extensively used in a wide range of scientific areas, such as sociology and psychology, studying individual and household decision making processes. However, it is still infrequent to find qualitative techniques in the travel behaviour literature to explore travel decisions (Mars et al. 2016). While quantitative data helps to understand 'what' is happening, qualitative data has a potentially valuable role in explaining the 'why' and 'how' dimensions (Chatterjee et al. 2013). Qualitative methods support a deeper understanding (Lambe et al. 2020) tailoring questions to responses that allow the participant to clarify, explain and elaborate on the responses (Clifton and Handy, 2003). Mars et al. (2016) emphasise how a qualitative approach in travel behaviour studies takes a subjective point of view as it focuses on the travel experiences of the individual. In contrast, a quantitative approach is more interested in knowing the frequency and distribution of the trips of a group of individuals (Mars et al., 2016). Qualitative approaches can provide in-depth insight into the experiences and processes of travel behaviour change (Jones and Ogilvie, 2012, Zarabi et al., 2019). This was explained by Regalado and Smale (2014) who found surveys gave little information about the lived experiences of students, whereas qualitative research allowed students to voice their experiences adding valuable detail about the college experience in terms of travel behaviour. As discussed in the literature (Chapter 2 Section 2.2), the transition from university education to the workforce results in travel behaviour changes brought about by the change in life events.

The COM-B model was used because it provides a simple framework for understanding behaviour (Gainforth et al., 2016). Compared to the TPB and DCE well-established behavioural models, the COM-B model is relatively new. As explained in Chapter 2, the use of the COM-B model would allow for the elicitation of a wider range of factors influencing participants' mode choice. The COM-B model posits behaviour to be a function of an individual's capability, opportunity, and motivation. Thus, for a given behaviour to occur, at a given moment, one must have the capability and opportunity to engage in the behaviour and the strength of motivation to engage in the behaviour must be greater than for any other competing behaviour (Michie et al., 2014). The behaviour under study was participants' travel choices during their time at university and as graduate employees. The aim was to elicit the factors pertaining to the participants' capability, opportunity and motivation when deciding which transport mode to use.

For a detailed understanding of the behaviour, the TDF domains were mapped onto the components of the COM-B model (Cane et al., 2012). The TDF provides an integrative framework which incorporates several constructs from a range of behavioural theories (Michie et al., 2005). This allowed for a more detailed behavioural analysis than it would have been possible using either individual theories or the COM-B model (Cane et al., 2012, Michie et al., 2005). The breadth and range of influencing factors suggested by the literature in influencing travel choices makes the COM-B model and TDF domains appropriate to use.

In addition to eliciting participants' barriers and facilitators when choosing their travel mode, the impact of transport policy measures was also explored. Throughout the progress of this thesis, the city of Birmingham, UK, was preparing for the launch of a Clean Air Zone (CAZ) and

Traffic Cells Initiative as part of a campaign to improve the air quality of the city centre. A CAZ is a specific geographical area where targeted action is taken to improve air quality by charging a daily fee to vehicle owners to enter, or move within, the zone if they are driving a vehicle that does not meet the emission standard for their vehicle type in that zone (DEFRA and DfT, 2020). The CAZ launched on 1st June 2021 (Figure 5A). This means diesel vehicles manufactured before 2015 and petrol cars made before 2006 are not allowed to enter the zone. Non-compliant cars entering the zone will have to pay a daily £8 charge. In addition to the CAZ, drivers are faced with restricted access due to the Traffic Cells Initiative (Figure 5B). This means, the city centre is segmented into six sections where only public transport can drive through segments and personal vehicles will have to turn around and enter different segments using the outside ring road. The impact of such measures is anticipated to change commuters' travel behaviour and perception of MaaS. Thus, questions pertaining to the appeal of MaaS and its suitability for participants travel needs were included. The following section presents details on the study context of this thesis.

A)

B)

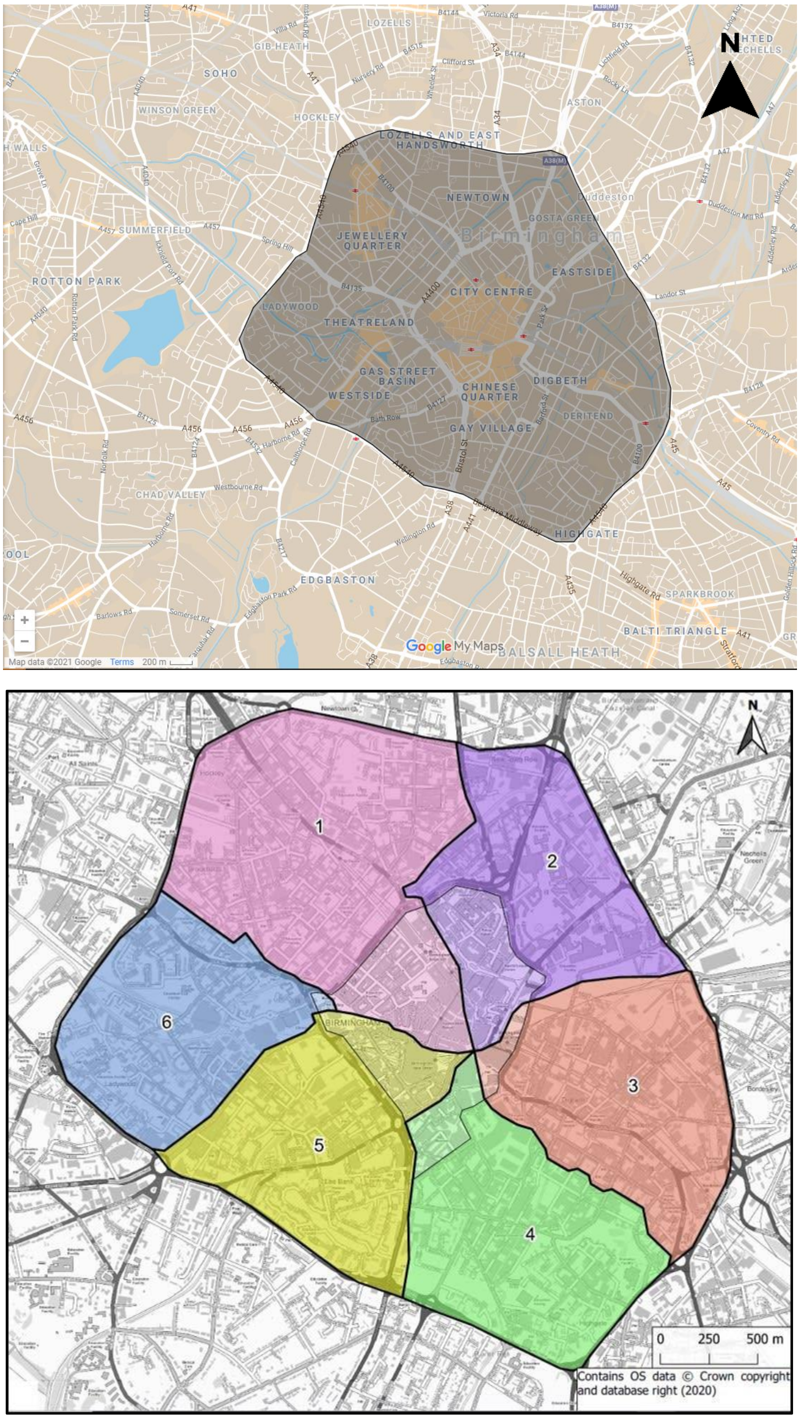


Figure 5: A) The Clean Air Zone covering all the roads within the A4540 Middleway Ring Road, but not the Middleway itself. (Google Maps, 2021a). B) City Centre Segments using the Traffic Cells Initiative (Birmingham City Council, 2020)

3.3 Study context

The first MaaS app in the UK was launched in the West Midlands by MaaS Global. The company MaaS Global introduced their multimodal transport application Whim to the West Midlands in April 2018 in partnership with Transport for West Midlands, part of the West

Midlands Combined Authority (WMCA). The introduction of a fully operational integrated transport system app was considered as one of the first commercialised MaaS products in the UK. The product was advertised as:

> "*a transport package tailored to an individual's needs across a number of different modes of public transport including buses, trams, taxis and hire cars, either as part of a monthly fee or on pay-as-you-go*".

The dense network of railway stations and buses organised by Transport for West Midlands and the presence of shared companies such as Gett taxis and Nextbike in Birmingham offered an ideal place where a multimodal transport application like Whim could be introduced.

Thus, the key motivation to use the West Midlands and the city of Birmingham (Figure 6) as the study location, was to identify the factors that can explain individuals' motivations and attitudes towards the hypothetical MaaS subscription. Additional reasons for choosing Birmingham included: 1) it is the second largest metropolitan city in the UK after London and so has a large number of commuters travelling to the city to work and study; 2) it has a high proportion of young adults (18-35 years old) due largely to students moving to the city to student at the city's universities (Birmingham City Council, 2020) and so provides an opportunity to study the potential of MaaS amongst this important age group; and 3) it has a dense network of transport services available to the public including shared mobility services, therefore offers the necessary infrastructure and services for a potential MaaS product to exist.

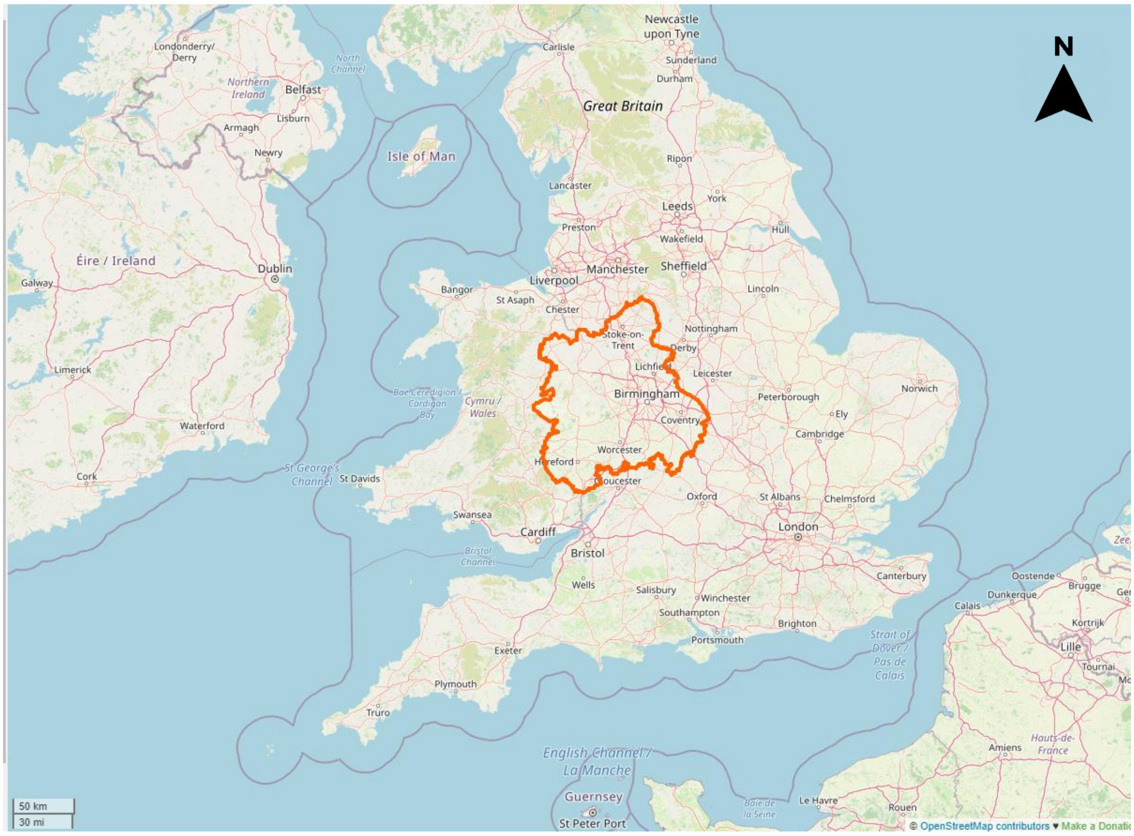


Figure 6: Map showing the West Midlands region boundary (OpenStreetMap contributors, 2021)

During the first year, the take up of MaaS in the West Midlands was reported to be slow and in 2019 the app went from offering three different subscription plans to offering only a pay-as-you-go option. Through personal communication with personnel at Transport for West Midlands, most of the subscribers were employees of Transport for West Midlands.

3.3.1 How do students and professionals travel in the West Midlands?

The Office for National Statistics (ONS) has data on the commuting patterns of men and women in the UK, including regional breakdowns by transport mode used to get to work (ONS, 2018). For the purposes of this study, the West Midlands statistics are of interest. The usual method of travelling to work for both men and women in the West Midlands was by car (78%) followed by walking (9%) and bus (6%). When travelling by car most people travel to work as a driver. Similarly, the typical travel behaviour of university students was explored using travel survey results conducted by universities in Birmingham. The location of the city's five universities is shown in Figure 7.

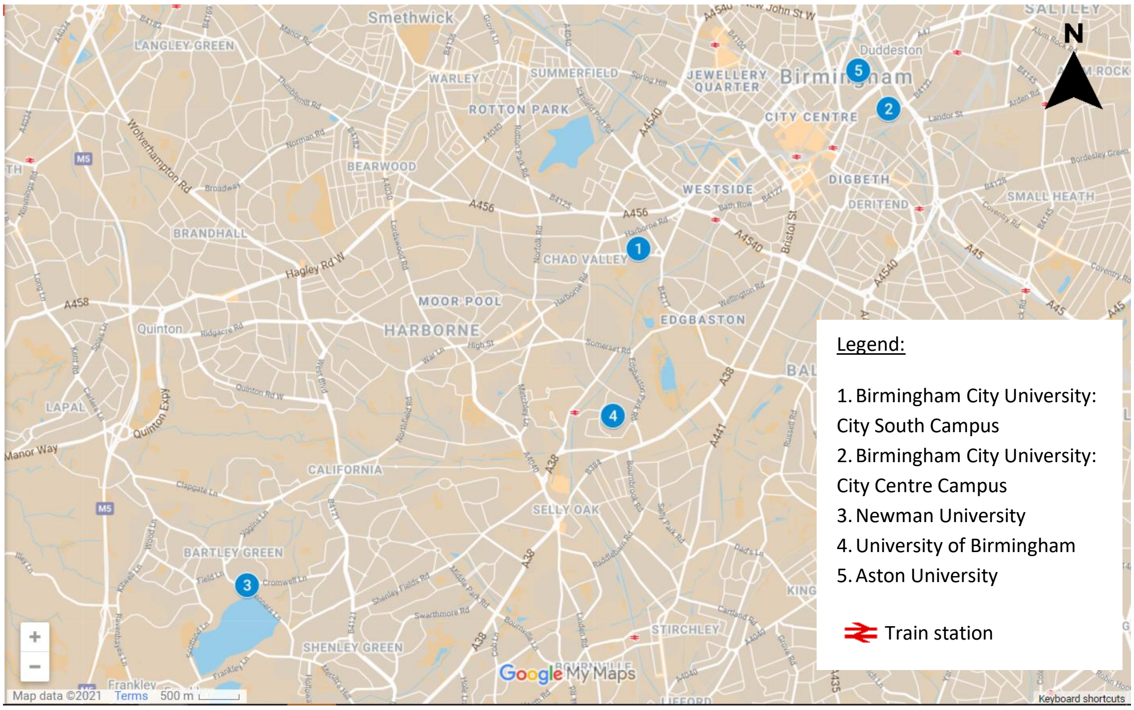


Figure 7: Map showing the location of the universities in Birmingham (Google Maps, 2021b)

The aim of travel surveys administered by universities is to address their commitment to reducing the number of single occupancy car journeys to the campus and to help both staff and students make more sustainable travel choices where possible. Table 7 provides an overview of how students and staff at each university in Birmingham travel. The surveys took a quantitative research method approach, however Birmingham City South campus and Aston University included a qualitative section in their surveys.

Table 7: Travel behaviour survey results for students and staff members attending universities located in Birmingham

University	Students and Staff type of commute
University of Birmingham (UoB, 2018)	Students more likely to walk (66.5%) or catch the train (11.7%). Staff are more likely to drive (34.5%) or catch the train (25.9%).
Birmingham City University (City centre campus) (BCU, 2020a)	Students more likely to ride the bus (29%), walk (27%) or catch the train (24%). Staff more likely to drive (34%) or catch the train (33%).

University	Students and Staff type of commute
Birmingham City University (City South Campus) (BCU, 2020b)	Students more likely to cycle and use the bus or train (31%) or the bus alone (24%). Staff more likely to drive (53%), catch the bus (15%) or train (13%).
Aston University (Aston University, 2019)	Students more likely to walk (34%) or use the bus (31%). Staff more likely to catch the train (25%) or drive (21%).
Newman University (Phil Jones and Associates, 2016)	40% of Students drive and 34% use the bus. Most staff (62%) drive while 15% use public transport.

A clear difference was found between Newman University students and the students attending the other universities. Students attending Newman University were found to mainly drive compared to students at other universities who used public transport or active modes of travel. Reasons for students having to use a car to commute to Newman University was attributed to the location of the university and lack of transport networks. This was confirmed by participants recruited for this thesis who described their complex and difficult commute to Newman University during interviews held for Chapter 6. Meanwhile, most university staff across the universities listed in Table 7 were found to drive with a small percentage saying to commute by public transport.

The qualitative sections asked staff and students reasons for their choice of transport modes. Staff and students attending Birmingham City South campus, said driving was quicker, easier, and more convenient. A significant number said that there was no suitable public transport where they lived and therefore had no alternative travel options (BCU, 2020b). With regards to the qualitative results for Aston University, staff said their choice of travel mode was based on cost, time, and other reasons such as childcare and reliability. Similarly, students attending Aston University said their choice of transport mode depended on how quick and cheap the commute was. When asked if they had changed how they travelled in the last two years, for both students and staff who stated yes, their reason for doing so was moving to a new house. Responses on what would encourage both staff and students to use public transport more, consisted of: discounts on public transport subscriptions; increased frequency of bus and rail services; safer public transport and flexible working hours for staff (Aston University, 2019).

The results provided in Table 7 for universities located in Birmingham were taken from the latest travel surveys conducted by the same universities. However, these reported travel patterns are considered to have been impacted in the first quarter of 2020 due to the global pandemic of COVID-19 which disrupted in-person learning. Universities and businesses shifted to an online presence as people were advised to socially distance and to work from home. Thus, technology replaced lecture rooms and virtual meetings replaced in-person business meetings. Hiselius and Arnfalk (2021) studied the role of digital technology during COVID-19 and reported how five public agencies in Sweden successfully shifted to telework and virtual meetings. This result shows the potential for digital tools to influence if and how we commute. Almost overnight, the COVID-19 pandemic phased out the need to physically commute to work or university; the long-term influence on commuting remains uncertain. The following section provides further information on the development of the global pandemic vis-à-vis the progress of this thesis.

3.4 The impact of COVID-19 on the research design

The first reports of an unknown virus in Wuhan, China began to spread across the world in December 2019 and on March 11, 2020, the World Health Organisation (WHO) Director General declared COVID-19 a global pandemic (WHO, 2020). On 23rd March 2020, the UK Government announced a national lockdown and previous advice on social distancing became legally mandatory. Figure 8 provides a timeline of when the national lockdowns took place together when studies related to this thesis were conducted.

Self-isolation and travel restrictions led to a dramatic reduction in the demand for passenger transport. Public transport was labelled as risky given that a person inside a vehicle is expected to stay in a limited space with no social distancing and with common surfaces being touched (Dingil and Esztergár-Kiss, 2021, Degli Esposti et al., 2021). On the 10th of May 2020, in a televised address to the nation, the UK Prime Minister urged people to avoid public transport when travelling to work to maintain social distancing. Thus, the working population was being encouraged to drive, cycle, or walk to work to reduce the risk of infection. The first questionnaire was conducted in 2019, hence the distribution and content of the study was not impacted by the measures for COVID-19. However, the DCE and interviews took place during the COVID-19 measures. An outcome was that clarity was necessary in setting up questions for respondents. This means respondents were briefed about which period the question on travel behaviour was related to, i.e., whether it was pre-pandemic (prior to March 2020) or during the pandemic.

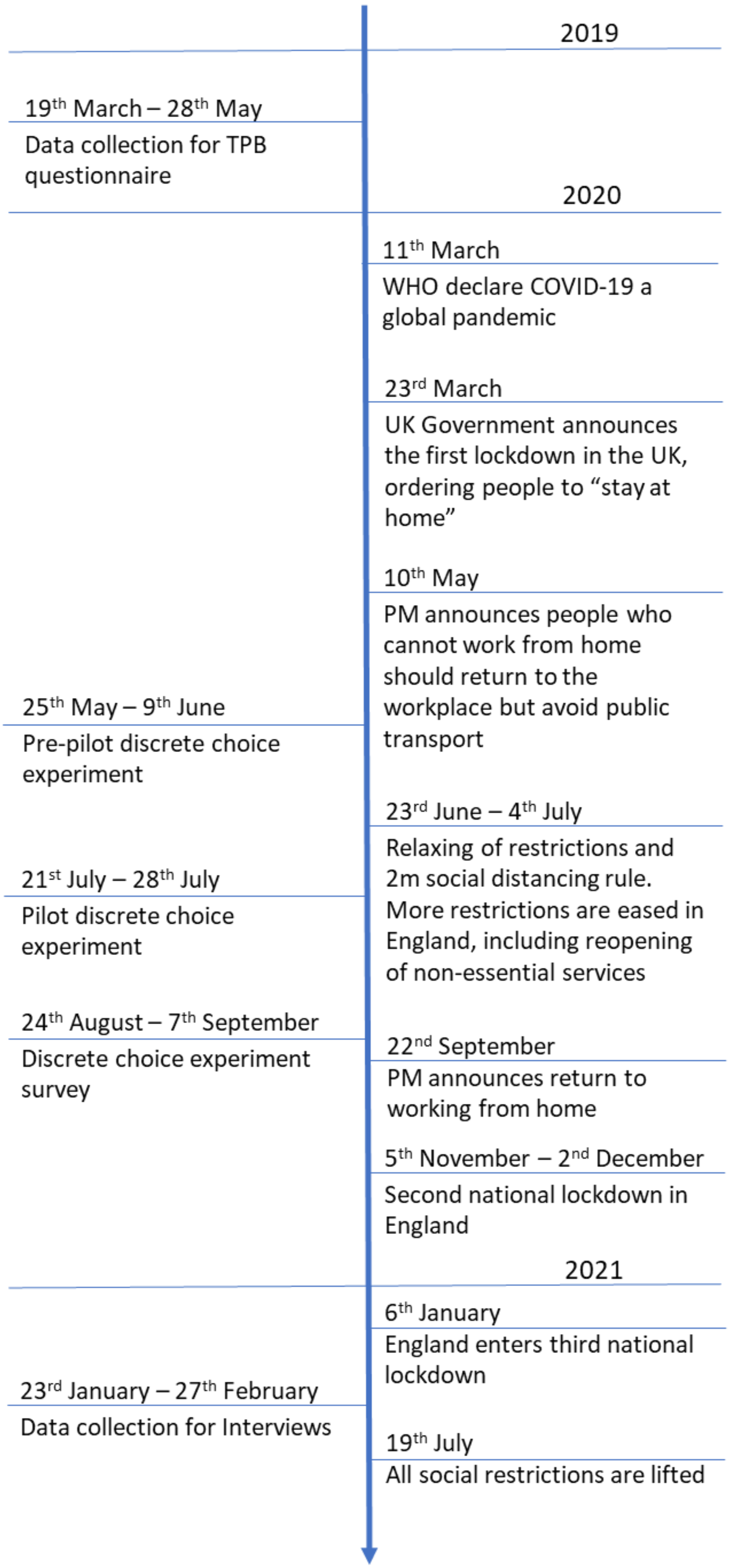


Figure 8: A timeline showing the advice given by the UK Government vis-à-vis the data collection conducted for this thesis

Chapter 4 Commuters' Intent to use MaaS

To examine the potential use of MaaS in Birmingham, the travel behaviour of commuters in the area under study is of interest. As explained in Chapter 3, the TPB was used to examine the psychological factors influencing commuters' intent to use public transport and shared mobility services for their everyday trips. This chapter outlines the methodology used and sampling strategy in Section 4.1. Detailed results and analysis are provided under Section 4.2 followed by the discussion of the results (Section 4.3) and limitations and future research (Section 4.4).

The aim of this chapter is to answer the following research questions:

- **RQ1a:** What determines multimodal travel behaviour?
- **RQ1b:** Which psychological factors influence the use of public transport and shared mobility services?

4.1 Methodology

4.1.1 Questionnaire

The questionnaire was designed to include questions measuring the three predictors of intention, and participants frequent use of private, public, and shared mobility services to measure multimodal travel behaviour. The questionnaire had four sections, starting with questions on participants travel behaviours, followed by questions measuring attitudes, subjective norms, PBC and intention and also sociodemographic characteristics. The final section presented participants with a description of what MaaS is and how it works followed by a few questions to test their knowledge on the concept and willingness to trial the service. An outline of the questionnaire items in each section is provided in Table 8 and a copy of the questionnaire is found in Appendix A. Details of each section of the questionnaire are provided below.

Section 1: Travel behaviours

In this section participants stated their use and the frequency of using different private, public, and shared mobility services during the previous month. A background check on the available transport modes in Birmingham ensured that participants filling in the questionnaire could find their respective transport mode. A pathway approach was applied throughout the questionnaire, whereby the response given in one question determined which question would follow. Hence, after selecting the transport modes used in the previous month, the selected modes were shown in the following question asking for the frequency of the used modes. The main transport mode used to commute to university or work, and leisure activities was asked together with the availability and frequency of public transport services close to home, work and places of leisure. Participants were also asked for their possession of mobility resources such as private car, bicycle, and public transport subscription. The final two questions asked participants whether they used trip planner apps or websites for their daily transport needs and if they had experience purchasing mobile travel tickets.

Section 2: Measuring attitudes, subjective norms, PBC and intention

Prior to answering the TPB questions, participants were provided with a short introduction to explain the target behaviour as shown in Figure 9. This was followed by a question where the participants rated their willingness to use public transport and carsharing, ridesharing and bike sharing which were collectively referred to as shared mobility services. Three different introductions were provided depending on whether the participant had a licence or owned a car. A participant who owned a car was shown the description in Figure 9. Participants who had a licence but did not own a car were shown the same introduction excluding any reference to the replacement of their private car. Participants who did not have a licence were shown the same introduction excluding any reference to carsharing which essentially requires the individual to hold a valid driving licence.

In this section you will be asked a series of questions relating to your opinion on using other means of transport instead of your private car. **Please keep in mind** that the following means of transport shall be collectively called 'shared mobility services and public transportation', these include:

> **Carsharing**: provide members with access to fleets of vehicles on a pay-per-use basis (e.g. enterprise carclub/co-wheels carclub/Turo)
>
> **Ridesharing**: when drivers of private vehicles pick up other passengers as part of a regular commute, or for specific journeys. Passengers pay the driver a fair price for the journey (e.g. Liftshare).
>
> **Bikesharing**: short-term bicycle rental, payment is based on the number of minutes used
>
> **Public transportation**: The bus, tram/metro and train services in Birmingham.

Figure 9: A short introduction was provided to the participants before attempting the questions related to the TPB

After having read the description, the participant was led to answer questions on intention, attitude, subjective norms and PBC.

Using direct measurements, attitudes were measured using bipolar adjectives (i.e., pairs of opposites) which are evaluative. The nine attitudinal elements used in the questionnaire were derived from previous studies (e.g., Haustein and Nielson, 2016, Şimşekoğlu et al., 2015, Busch-Geertsema and Lanzendorf, 2017). These included instrumental items and experiential items as specified by Ajzen (2006) and Francis et al. (2004). Instrumental items measured attitude directly by asking whether the behaviour would achieve a positive or negative effect and experiential items measured attitude on how it felt to perform the behaviour. Instrumental items included cost, convenience, environmental benefit, and flexibility. Experiential items included pleasant, safety, relaxing and excitement. The final item in the set was a good-bad scale which is recommended by Ajzen (2006) and Francis et al. (2004) to be included as a reflection of the overall experience of the behaviour. A few of these items were negatively worded endpoints, which were recoded, so that higher numbers would reflect a positive attitude to the target behaviour.

Direct measurements of subjective norms included questions referring to the opinions of important people in general. Such questions reflect the social pressure on the participant to perform the target behaviour. As explained by Ajzen (2006) the direct measures of subjective norms are injunctive norm, referring to pressure from important people to perform a behaviour and descriptive norm, referring to how significant people behave. Hence, subjective norms were assessed directly using six statements.

PBC refers to the extent a person feels capable and has control over performing a behaviour. The direct measures of PBC include self-efficacy, referring to how easy or difficult a person believes it is to perform a behaviour; and controllability, referring to whether factors are within or beyond control. Self-efficacy is suggested to be predominantly dependent on internal factors such as ability, perceived inconvenience, and willpower (Armitage and Conner, 1999, Terry and O'Leary 1995). For this study, the control beliefs of self-efficacy were measured using statements outlined by Ajzen (2006) and Francis et al. (2004). Self-efficacy was assessed by asking participants to report how easy or difficult it was to perform the behaviour and how confident they were that they could use such services. Whereas perceived controllability is suggested to be predominately dependent on external factors such as available resources and opportunities (Armitage and Conner, 1999, Terry and O'Leary 1995). For this study, control beliefs of perceived controllability were measured using statements as outlined by Ajzen (2006) and Francis et al. (2004). Controllability was assessed by asking people to report whether performing the behaviour was up to them or whether factors beyond their control determined their behaviour. Hence, PBC was assessed directly using four statements.

The intention of using shared mobility services and public transport for everyday trips was asked using the three direct measures specified in the guidelines by Ajzen (2006) and Francis et al. (2004). Unless indicated otherwise, for all the direct measurements of the TPB, participants had a 5-point Likert scale to rate how much they agreed with the statements.

Section 3: Sociodemographic characteristics

This section included sociodemographic questions which studies had found influential of mode choice: age, gender, location, education, employment status and housing tenure.

Section 4: MaaS questions

In this section the concept of MaaS was introduced and participants' knowledge of MaaS was assessed using three multiple choice questions, followed by questions on their likelihood of using MaaS. The requirement to answer this section was optional and participants were offered an incentive (being entered twice in the prize draw) to complete this section of the questionnaire. This was done to encourage participants to complete the survey in full.

Table 8: Questionnaire outline including question items and section theme

Questionnaire Section	Theme	Question items
Section 1	Travel Behaviour	• Previous use and frequency of transport modes • Preferred mode of travel to university/work/leisure • Number of journeys in a week • Distance and journey time taken • Mobility tools such as transport passes and driving licence • Ownership of car and bicycle • Use of trip planners and mobile tickets
Section 2	Theory of Planned behaviour (TPB)	• The extent to which participants would use carsharing, ridesharing, bike sharing and public transport

Questionnaire Section	Theme	Question items
		• Three questions measuring participants' intention towards using public transport and shared mobility services for everyday trips • Nine adjectives measuring participants' attitudes towards using public transport and shared mobility services for everyday trips • Six questions measuring participants' subjective norms towards using public transport and shared mobility services for everyday trips • Four questions measuring participants' PBC towards using public transport and shared mobility services for everyday trips
Section 3	Sociodemographic	• Age • Gender • Post Code Location • Employment status • Level of Education • Housing tenure
Section 4	Mobility as a Service	• Three questions to measure the level of understanding of MaaS • Knowledge and awareness of MaaS • Confidence and likelihood of using MaaS

4.1.2 Questionnaire pre-test and pilot

The importance of conducting a pilot test for this study is explained by Bloomberg and Volpe (2008) where it enables the researcher to refine the approach of recruiting participants, the questions, instrument, and procedures of the study and thereby make improvements that would be beneficial in the final analysis. The questionnaire was pre-tested with young adults studying at a UK university and others in employment. Participants were asked to provide open feedback on the content of the questionnaire. An issue identified by the participants was the need for a progress bar. Suggestions to clarify questions and change words were also provided. Based on the open-ended feedback received from the pre-test participants, the survey instrument was revised and refined through an iterative process and subjected to the pilot testing phase. The pilot questionnaire was deployed in the field for a period of 2 weeks (21st February to 7th March 2019).

The pilot test closely represented the actual survey administration protocol. A convenience sample of students and workers from one university in Birmingham were recruited to participate in the pilot. The pilot survey was administered through an online web-based interface allowing for various strategies to be employed during the pilot survey administration process in order to maximise response rates and enhance the quality of data collected from the questionnaire. One of the lessons was to design an advert for the study which was attractive for the target participants and appropriate for social media dissemination.

4.1.3 Questionnaire launch

Once the questionnaire was finalised the deployment of the questionnaire in the field was challenging. To incentivise participants into taking the survey and completing it, entry into a free prize draw to win one of five Amazon vouchers was offered. To reach the student sample the researcher contacted sustainable transport representatives at the four main universities located in Birmingham: University of Birmingham, Birmingham City University, Aston University and Newman University. During the data collection phase, Birmingham City University and Aston University joined forces for a week-long campaign that aimed to encourage sustainable behaviour for staff and students. The campaign took place between 18th and 22nd March 2019. With prior consent from the organisers of the campaign, the researcher had the opportunity to present the study to students and staff at Aston University and Birmingham City University. This opportunity also allowed the researcher to recruit participants for the study. During this visit, contacts were also made with Transport for West Midlands who shared the study with their social media followers. This meant the workers sample could also be reached. However, to increase participant recruitment, the researcher got in touch with corporate companies located in Birmingham, to share the study with their employees using their local internal communications.

Overall, the survey was distributed among university networks, corporate networks and social communities on social media platforms attracting participants that fit the study criteria of being a student attending a university in Birmingham or an individual employed in Birmingham.

4.1.4 Statistical analysis

IBM SPSS Statistics version 25 was used to analyse the data. Correlations and linear regression analysis were used to test the hypothesised associations with the intention to use shared mobility services and public transport for everyday trips in Birmingham. Chi-square and logistic regression analyses were used to test the hypothesised association with being multimodal using descriptive statistics. All categorical variables were converted into dummy variables in order to be included in the bivariate analyses and linear regression analyses.

Factor analysis was used as a data reduction technique to determine whether items of the TPB were measuring the same construct. Factor analysis (principal components analysis with orthogonal rotation) was conducted on the direct measures of intention, attitude, subjective norms and PBC. The final set of factors were tested for their reliability using Cronbach's alpha to identify how well the items grouped were positively correlated to one another.

4.2 Results and analysis

The total eligible sample consisted of 477 participants, 190 students attending a university in Birmingham and 287 workers employed in Birmingham. Given the questionnaire had four sections, 85 respondents chose to terminate their response after completing the first or second section, with 392 participants completing the questionnaire. Nevertheless, each section corresponds to the research questions and therefore where possible, all available responses were analysed. The rest of this chapter describes the participants in terms of their sociodemographic characteristics and travel behaviour patterns from which traits for multimodal travel behaviour were explored. The second section presents the results of the TPB model examining the importance of attitude, subjective norms and PBC on participants' intention to use shared mobility and public transport services.

4.2.1 Sociodemographic characteristics and mobility tools

The questionnaire collected data on participants' sociodemographic characteristics, current travel behaviour and mobility tool ownership (Table 9). These were important to examine participants' travel behaviour constraints and multimodal travel behaviour.

The workers sample mainly consisted of workers engaged in full-time employment. Slightly less than half of the student sample worked part-time alongside their studies implying that such students had work commute commitments in addition to that of university. In terms of the level of education, more than half of the workers' sample was composed of highly educated people and more than half of the students were enrolled in a master's degree or a PhD. These results were expected given the survey was distributed using university networks and corporate companies located in Birmingham. The average age of the workers' sample was 38 (SD=11.66, n=243) and for the student sample the average age was 27 (SD=8.45, n=149). The ages were consistent with the aim of recruiting the potential end users of MaaS as described in Section 3.2.1.

With regards to gender, both the student and worker samples recorded high rates of female respondents. To explain the high rate of female respondents, reference is made to a PhD study by Smith (2008) who analysed gender influence in online survey participation. Smith (2008) found females were more likely to engage in online activity characterised by communication and exchanging of information whereas males were more likely to engage in online activity characterised by seeking of information. This meant females are more likely to respond to an online survey. In addition, the number of females in higher education was higher than males (HESA, 2021a) and with regards to the number of females and males residing in Birmingham, there are more females than males in the adult ages (over 18 years) (Birmingham City Council, 2019).

In terms of housing tenure, Mann-Whitney U tests show a significant distinction between students and workers in terms of home ownership (U=9629, p=.000), living in a parental or guardian home (U=13554, p=.000) and living in a rented property (U=14347, p=.000). The results of housing tenure were also used as a marker of income for the purposes of this study (Dalstra et al., 2006).

Variables which are known to influence mode choice are participants' ability to travel and access to mobility services such as a car, bicycle, and public transport subscription. Most participants said they did not suffer from any long term physical or health issue that limits their ability to travel. Therefore, most participants were able to use transport services without any physical difficulty.

As expected, most car owners were workers. A Mann-Whitney U test shows there was a significant difference in car ownership (U=8284, p=.000) and bicycle ownership (U=20124.5, p=.010) between students and workers. In terms of being in possession of a public transport subscription, the most popular public transport subscription was the rail card for both students (48.3%) and workers (26.0%) followed by the bus subscription for students (16.9%) and a Swift card subscription for workers (20.1%). The Swift card is a multimodal travel subscription covering the cost of the bus, train, and tram for travel exclusively within the West Midlands.

To assess participants' experience with using their smartphone for travel purposes, participants were asked about their use of transport planner apps or websites, to find information for their daily transport needs when travelling in Birmingham. A Mann-Whitney U test shows there was no significant difference between students and workers use of trip planners ($U=22183.5$, $p=.709$) and purchase of mobile travel tickets ($U=21112.5$, $p=.120$). The results show that, more than half of the participants for both groups said they did use trip planner apps and had experience purchasing travel tickets using their smartphone.

Table 9: Sociodemographic characteristics of the student and worker sample

Variable	Items	Worker %	Worker sample	Student %	Student sample
Age	Age 18 to 24	9.8	n=244	50.3	n=149
	Age 25 to 31	22.5		32.2	
	Age 32 to 38	21.7		8.1	
	Age 39 upwards	45.9		9.4	
Gender	Male	34.4	n=244	25.5	n=149
	Female	64.8		73.2	
	Other	0.8		0.7	
	Prefer not to say			0.7	
Educational Level completed/currently studying	GCSE/O-Level	7.4	n=243	-	n=149
	A-Level	11.2		-	
	Bachelor's degree	40.1		43.0	
	Master's Degree	23.6		27.5	
	Doctoral or Professional Degree	10.7		28.9	
	Vocational Qualification	7.0		-	
Employment Status	Working full-time/Full-time	77.4	n=243	51.0	n=149
	student	15.6		44.3	
	Working part-time	2.1		-	
	Employed full-time and self-employed part-time	2.1		-	
	Working full-time self-employed	1.2		-	
	Working part-time – self employed	1.6		4.7	
	Other				

Variable	Items	Worker %	Worker sample	Student %	Student sample
Housing tenure	Parental/guardian home	11.1	n=243	36.2	n=149
	Owned residence	60.9		14.1	
	Rented property	27.6		48.3	
	Other	0.4		1.3	
Driving Licence	Yes	81.8	n=269	54.7	n=172
	No	16.4		29.1	
	Learning to drive	1.9		16.3	
Car Access	Own	83.5	n=224	45.9	n=122
	Someone else	9.8		21.3	
	No access	6.7		32.8	
Bicycle Access	Own	43.7	n=268	30.2	n=172
	Someone else	4.1		6.4	
	No access	52.2		63.4	
Mobility difficulties	No	88.9	n=243	89.3	n=149
	Yes	9.1		6.7	
	Prefer not to answer	2.1		2.0	
	Don't know	0.0		2.0	
Mobility transport subscription (percentages show number of participants who are in possession of a transport subscription)	Bus	15.6	n=269	16.9	n=172
	Rail Card	26		48.3	
	Metro Only	0.7		0	
	Metro and Bus	2.2		1.7	
	Metro, Bus and Rail	2.2		3.5	
	Coach	1.1		0.6	
	Car Club	2.2		0	
	Bike Share	0		0	
	Swift Card	20.1		14	
	Parking Permit	16.4		9.9	
	Other	1.9		0.6	
	None	33.8		22.7	
Use of a trip planner	No	31.7	n=268	33.7	n=172
	Yes	66.8		65.7	
	Don't know	1.5		0.6	
Use of smartphone to purchase mobile travel tickets	No	44.8	n=268	37.2	n=172
	Yes	54.9		62.2	
	Don't know	0.4		0.6	

4.2.2 Travel behaviour patterns

In terms of how participants commute and the frequency, Table 10 provides the average number of journeys, distance travelled, and time taken per journey for both workers and students. The number of commuting journeys workers made was slightly more than students. This was anticipated considering workers in full-time employment are expected to work 5 days a week whereas students might not always need to commute to campus for lectures all days of the week. The number of journeys made for leisure activities by workers and students was similar. In terms of the distance travelled and commute journey time, although the results show students to have a slightly longer journey time this would be dependent on the transport mode being used. The following section presents the transport modes used by workers and students.

Table 10: Travel behaviour of students and workers for both commute and leisure activities

		Commute to work or university Mean (SD)		**Commute to leisure activities Mean (SD)**
Number of one-way journeys per week	**Workers (n=272)**	9 (2.28)	**Workers (n=253)**	4 (3.06)
	Students (n=183)	7 (3.91)	**Students (n=158)**	4 (4.18)
Distance travelled (miles) per journey	**Workers (n=269)**	10.44 (11.15)	**Workers (n=268)**	9.75 (13.79)
	Students (n=168)	11.38 (19.33)	**Students (n=158)**	8.95 (12.48)
Commute journey time (minutes)	**Workers (n=272)**	41 (23.06)	**Workers (n=263)**	30 (21.22)
	Students (n=184)	43 (36.11)	**Students (n=170)**	33 (24.50)

As shown in Figure 10 the main transport modes used by students to travel to university was the bus or by walking while a small number reported to driving or catching the train. In contrast, the workers' sample was found to mainly commute by car or by train although a small number of participants reported taking the bus to work. Both students (94.9%, n=177) and workers (88.2%, n=271) reported having public transport services within walking distance from where they lived with a frequency of more than once an hour or every few minutes. With respect to the available public transport modes at university campuses, the dense network of rail and bus services in Birmingham were found to be available within walking distance from university campuses. On the other hand, when workers were asked if they had public transport services available within walking distance from their place of work, 97.7% (n=265) responded positively reporting the frequency to be more than once an hour (42.1%, n=259) or every few minutes (42.9%, n=259).

When travelling for leisure purposes no changes were found for the worker sample as the private car and the train remained the main transport modes. However, for the student sample a change was recorded in the transport modes being used. Many students travelled to their leisure activities by train, with most of the leisure activity places reported by students (89.9%, n=158) to be within walking distance of public transport services and having a frequency of every few minutes (50.0%, n=142) and more than once an hour (35.9%, n=142). Similarly, the availability of public transport modes close to the leisure activities attended by workers was reported to be within walking distance by 83.9% (n=249) with the frequency of the services being more than once an hour (46.9%, n=209) and every few minutes (37.3%, n=209).

Using the travel behaviour data collected, multimodal travel behaviour and factors influencing such travel behaviour, are discussed next.

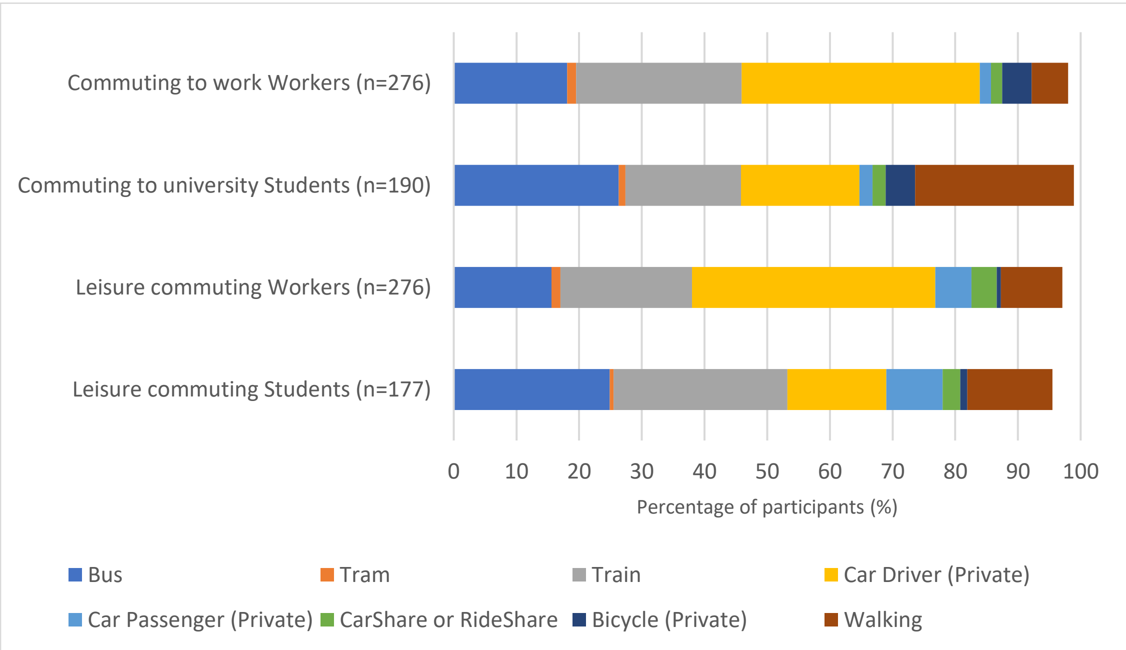


Figure 10: Main transport modes used by students and workers to commute to work or to university and leisure activities

4.2.3 Multimodal travel behaviour

Participants were asked to indicate the frequency of transport modes used for all types of activities including weekdays and weekends, ranging from 'every day' to '1 to 3 times a month', taking the previous month as an example. Participants using two or more transport modes (excluding walking) within a week were labelled as multimodal. The number of workers labelled as multimodal were 128 (44.6%, n=287) and the number of students labelled as multimodal were 74 (38.9%, n=190).

As shown in Table 11, a clear distinction was found in the transport modes used by multimodal workers and students. As expected, most workers used their private car when using other transport modes, while the majority of the student sample used the bus. The second type of transport mode used by both workers and students was the train.

Table 11: Number of multimodal workers and students found in the sample and their main transport modes

Variable	Items	Worker %	Worker sample	Student %	Student sample
Multimodal	Multimodal	44.6	n=287	38.9	n=190
	Not multimodal	55.4		61.1	
Multimodal travellers use of transport modes >=1 day per week	Car driver (Private)	64.8	n=128	21.6	n=74
	Train	51.6		43.2	
	Bus	42.2		62.2	
	Car passenger (Private)	37.5		33.8	

Based on the literature review in Chapter 2 research studies have mainly distinguished multimodal from non-multimodal travellers using sociodemographic variables such as gender, age and education, and mobility access variables such as car ownership, bicycle ownership and driving licence (Molin et al., 2016, Buehler and Hamre, 2015, Heinen and Chatterjee, 2015). Therefore, the following section uses these factors to explore the characteristics of multimodal travellers in Birmingham.

4.2.4 Exploring multimodal travel behaviour

This section presents the results of the hypotheses presented under Research Question 1 in Section 3.2.2 using mobility constraints and sociodemographic variables to explore multimodal travel behaviour. The hypotheses were tested using Pearson's correlation coefficient for continuous variables and chi-square tests for dichotomous variables.

As shown in Table 12, most of the tests did not indicate a statistical significance between the variables (values were above the p-value of .05). This implies that in each case, the null hypothesis is accepted. Nevertheless, a few tests indicated statistical significance for either the worker or student sample, implying that the null hypothesis is rejected. The variables found to be statistically significant for either the worker or student sample demonstrates how different variables influence multimodal travel behaviour for the two groups. Several studies have discussed how workers and students have different travel patterns and factors that influence their choices (Romanowska et al., 2019). Therefore, a decision was taken to assess each group separately.

Chi-square tests of independence confirmed a significant association between multimodal students and car ownership, mobility difficulties, the possession of a rail card subscription and commuting a distance between 5.8 and 12 miles to university. For the workers sample, the chi-square test of independence confirmed a significant association between multimodal workers and access to public transport services close to the place of work, a commute distance of 13 miles or more, a commute distance between 2.7 and 5.7 miles, employment status and being 39 years or older. The hypothesised associations with being multimodal were tested in a multivariate model using a binomial logistic regression to identify the direction and strength of the relationship, something which the chi square test does not allow for. A decision was taken to also include the variables which were not found to have a significant relationship since the literature suggests that these factors should affect multimodal travel behaviour.

Table 12: List of hypotheses to predict multimodality for workers and students

Hypothesis: Being a multimodal transport user is associated with…	**Worker**	**Null hypothesis**	**Student**	**Null hypothesis**
Being female	χ^2 (1, n= 242) =.108, p=.743	Accepted	χ^2 (1, n=147) =1.118, p=.290	Accepted
Long term physical or health issue that limits ability to travel	χ^2 (1, n=238) =.058, p=.290	Accepted	χ^2 (1, n=143) =4.754, p=.029, Fisher's exact test = .042	**Rejected**
Age 39 and older	χ^2 (1, n=244) =3.937, p=.047	**Rejected**	χ^2 (1, n=149) =.697, p=.404	Accepted
Own residence	χ^2 (1, n=243) =.146, p=.703	Accepted	χ^2 (1, n=149) =.322, p=.571	Accepted

Hypothesis: **Being a multimodal transport user is associated with…**	**Worker**	**Null hypothesis**	**Student**	**Null hypothesis**
Employment Status	χ^2 (1, n=239) =5.340, p=.021	**Rejected**	χ^2 (1, n=149) =.196, p=.658	Accepted
Driving licence	χ^2 (1, n= 269) =.002, p=.964	Accepted	χ^2 (1, n= 172) =3.112, p=.078	Accepted
Car ownership	χ^2 (1, n=224) =.138, p=.710	Accepted	χ^2 (1, n=122) =5.255, p=.022	**Rejected**
Rail Card subscription	χ^2 (1, n= 269) =1.396, p=.237	Accepted	χ^2 (1, n= 172) =3.925, p=.048	**Rejected**
Owning a bicycle	χ^2 (1, n=268) =.258, p=.612	Accepted	χ^2 (1, n=172) =.064, p=.800	Accepted
Commute distance (continuous)	r=-.115, p=.059	Accepted	r=-.135, p=.080	Accepted
Commute distance 2.6miles or less	χ^2 (1, n=280) =2.199, p=.138	Accepted	χ^2 (1, n=168) =.2.094, p=.148	Accepted
Commute distance 2.7 to 5.7 miles	χ^2 (1, n=280) =5.273, p=.022	**Rejected**	χ^2 (1, n=168) =.601, p=.438	Accepted
Commute distance 5.8 to 12 miles	χ^2 (1, n=280) =.1.908, p=.167	Accepted	χ^2 (1, n=168) =4.552, p=.033	**Rejected**
Commute distance 13 miles and more	χ^2 (1, n=280) =6.819, p=.009	**Rejected**	χ^2 (1, n=168) =1.098, p=.295	Accepted
Access to public transport services close to home	χ^2 (1, n=269) =1.628, p=.202	Accepted	χ^2 (1, n=177) =3.320, p=.068, Fisher's exact test=.087	Accepted
Access to public transport services	χ^2 (1, n=265) =4.779, p=.029,	**Rejected**	Not applicable	Not applicable

Hypothesis: Being a multimodal transport user is associated with…	Worker	Null hypothesis	Student	Null hypothesis
close to the place of work	Fisher's Exact test=.037			
Trip planner use	χ^2 (1, n=264) =.071, p=.790	Accepted	χ^2 (1, n=171) =3.194, p=.074	Accepted
Purchase of mobile tickets	χ^2 (1, n=267) =.141, p=.707	Accepted	χ^2 (1, n=171) =.992, p=.319	Accepted

Table 13 shows the logistic regression coefficient, Wald test and odds ratio for each of the predictors of multimodality for the students' sample. The logistic regression model was not statistically significant χ^2 (9) = 12.598, p=.182 and explained 18.8% (Nagelkerke R^2) of the variance in being multimodal and correctly classified 74.2% of cases. The statistically insignificant regression model can be related to the homogenous characteristics of age, mobility tool ownership and commute distance of this sample. Therefore, we would not expect to find different behaviour patterns. This was also found in Mokwena and Zuidgeest (2017) whereby student demographics tended to be insignificant in the model suggesting that the population is homogenous. This makes it difficult to predict students who are multimodal based on sociodemographic and travel behaviour variables alone. Therefore, other factors would need to be identified to explain multimodal travel behaviour for students. Factors such as income, household type and location have been found to be influential factors defining multimodality for students (Kuhnimhof et al., 2012b, Grimsrud and El-Geneidy, 2013). Nevertheless, out of the nine predictor variables the rail card subscription was found to be statistically significant with a negative coefficient sign. This was unexpected given rail users would need to use other transport modes for their first or last mile to connect them to the station. Therefore, this result demonstrates how the dense network of railway stations spreading across Birmingham and nearby towns allows rail users to walk to and from the station without the need of using other transport modes except for rail.

Table 13: Summary of logistic regression analysis of factors predicting multimodality for the student sample

Predictor	B	Standard Error B	Wald	Sig.	Exp(B)
Mobility difficulties (0=no, 1=yes)	.371	1.309	.080	.777	1.449
Student employment status (0=full-time student, 1=full-time student with part-time job)	.160	.511	.098	.754	1.173
Bicycle ownership (0=no, 1=yes)	-.644	.508	1.604	.205	.525
Car ownership (0=no, 1=yes)	.377	.518	.529	.467	1.457
Rail card Subscription (0=no, 1=yes)	-1.336	.575	5.397	.020	.263
Commute distance 5.8 to 12 miles (0=no, 1=yes)	.219	.620	.125	.724	1.245
Gender (0=female, 1=male)	-.463	.597	.601	.438	.629
Trip planner use (0=no, 1=yes)	.812	.573	2.006	.157	2.253
Purchased mobile tickets (0=no, 1=yes)	.637	.528	1.454	.228	1.890
Constant	-.762	.743	1.049	.306	.467

Note: n=89, Cox & Snell R^2 = .132; Nagelkerke R^2=.188; χ^2 = 12.598, p=.182, df= 9

Table 14 shows the logistic regression coefficient, Wald test and odds ratio for each of the predictors of multimodality for the workers' sample. The logistic regression model was statistically significant χ^2 (10) = 22.382, p=.013 and explained 15.3% (Nagelkerke R^2) of the variance in being multimodal and correctly classified 65.4% of cases. Of the ten predictor variables three predictors were found to be statistically significant: employment status, commute distance and age. Compared to older employees, young employees were expected to be multimodal since multimodality traits are known to be found among young adults who are open to using different transport modes (Kuhnimhof et al., 2012b, Jamal and Newbold, 2020). The commute distance shows multimodal workers were more likely to commute 13 miles or less showing the availability of transport services within a 13-mile radius to service multimodal travel behaviour. In contrast to the literature (Heinen and Chatterjee, 2015), in this study workers in full-time employment were found more likely to be multimodal. One of the reasons full-time employees travelling in Birmingham might be multimodal is that companies have the option to offer workers a corporate Swift card. The latter is a smart card which is topped up with a certain amount of travel budget and which can also track journeys to avoid the use of travel expense claim forms. This result further gives importance to the provision of a corporate integrated mobility subscription to encourage workers to use public transport and shared mobility services. The availability of public transport services located close to participants' place of work and the dense network of rail and bus services across Birmingham and the West Midlands, provide workers with a good transport network that makes it possible to commute by public transport.

Table 14: Summary of logistic regression analysis of factors predicting multimodality for the worker sample

Predictor	B	Standard Error B	Wald	Sig.	Exp(B)
Gender (0=female, 1=male)	.268	.349	.590	.443	1.307
Mobility difficulties (0=no, 1=yes)	1.158	.673	2.962	.085	3.184
Age 39 and older (0=no, 1=yes)	-.783	.368	4.536	.033	.457
Employment Status (0=part-time, 1=full-time)	1.385	.566	5.986	.014	3.995
Car ownership (0=no, 1=yes)	.146	.454	.104	.747	1.158
Rail card Subscription (0=no, 1=yes)	-.370	.389	.904	.342	.691
Bicycle ownership (0=no, 1=yes)	.520	.331	2.468	.116	1.683
Commute distance 13 miles or more (0=no, 1=yes)	-.857	.415	4.262	.039	.424
Own residence (0=no, 1 =yes)	.547	.388	1.983	.159	1.728
Available public transport services close to home (0=no, 1=yes)	.300	.536	.313	.576	1.249
Constant	-2.008	.878	5.230	.022	.134

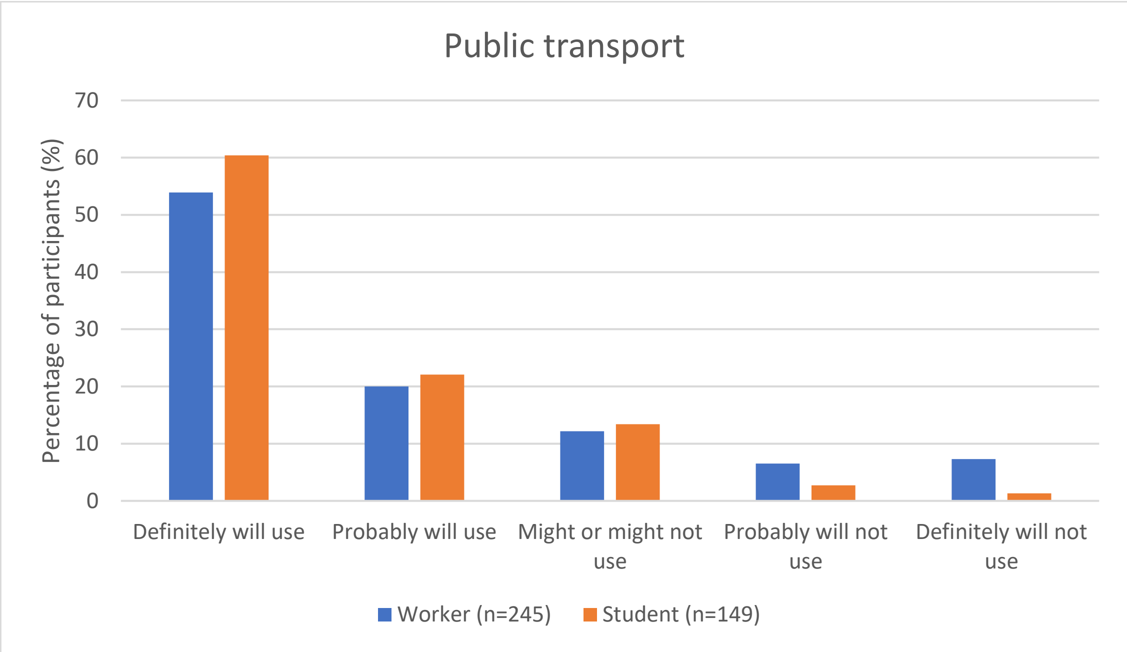
Note: n=185, Cox & Snell R^2 = .114; Nagelkerke R^2=.153; χ^2 = 22.382, p=.013, df= 10

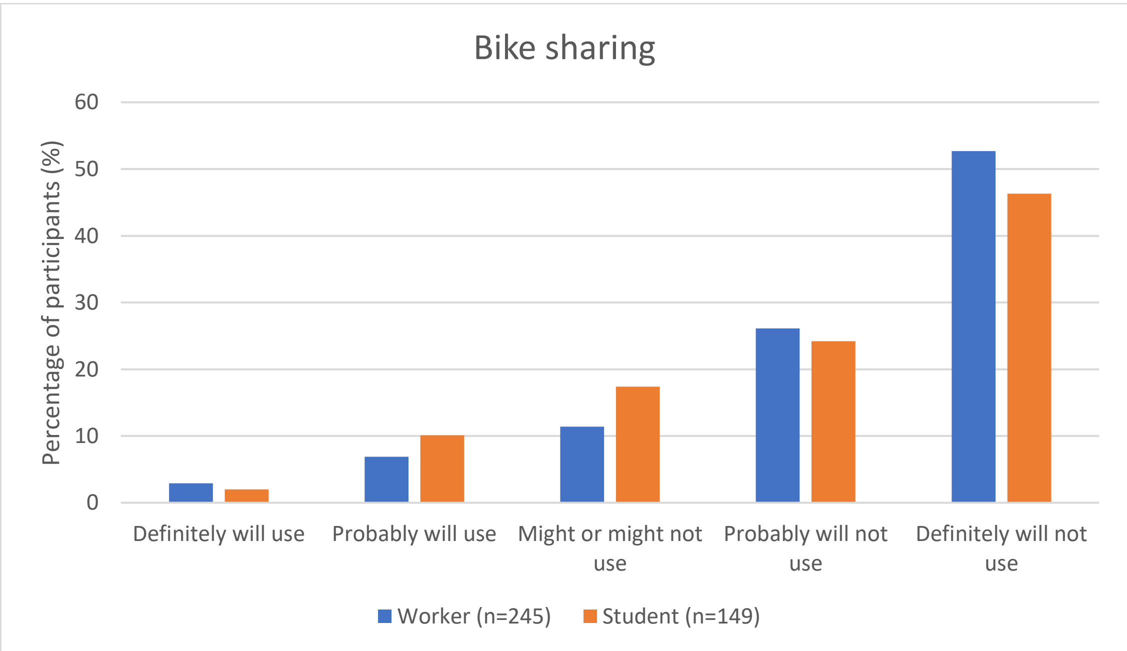
4.2.5 Measuring intention using the TPB

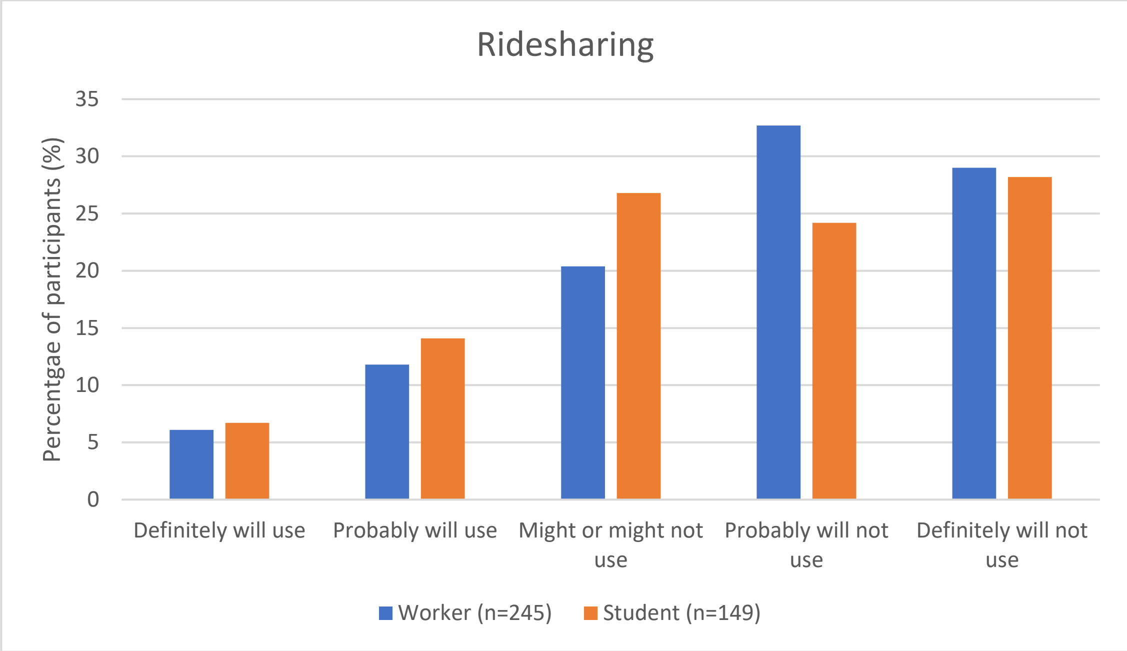
In total, 245 workers and 149 students completed the questions pertaining to the TPB. Thus, the following results are based on these number of participants unless stated otherwise.

Prior to answering questions related to the TPB, participants were asked how likely they were to use each of the transport modes included in the target behaviour. The carsharing option was only available to rate for respondents who had a driving licence (Students n=104, Workers n=204). Overall, combining the results of the 'definitely will use' and 'probably will use', the results show students rated each of the transport modes more positively than workers did, except for carsharing (Figure 11). Given most workers were car owners (83.8%, n=204), the results show how workers would prefer to stick to the automotive vehicle when provided with an alternative option to the private car.

As expected, the highest rated preferred transport mode was public transport which included buses, trains, and trams for both students (82.5%) and workers (73.9%). The least preferred transport mode was bike sharing for both groups (70.5% students, 78.8% workers).







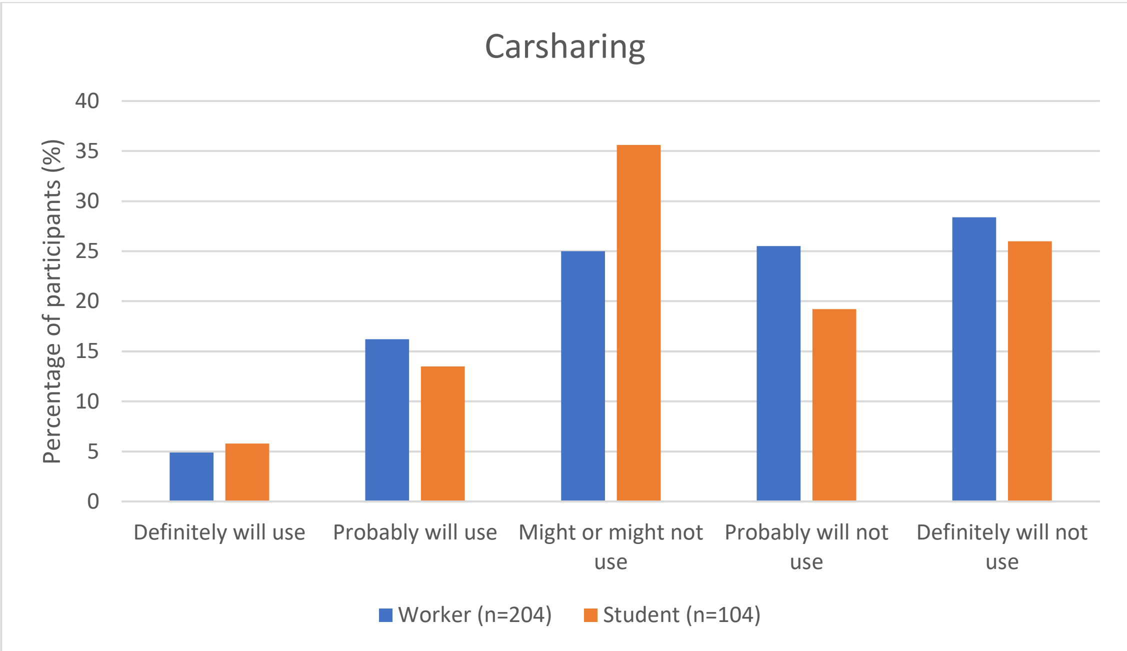


Figure 11: The percentage of participants rating the likelihood of using alternative transport modes

Participants were then asked if they plan, try, and intend to use shared mobility services and public transport for their everyday trips. The current use of public transport and shared mobility services by participants is assumed to be reflected in these results. Students' intention for using public transport and shared mobility services was found to be higher than workers (Figure 12). A Mann-Whitney U test shows that there was a significant difference for between intent (U= 15195.5, p=.004), try (U= 15741.5, p=.019) and plan (U= 15705, p=.017), between students and workers.

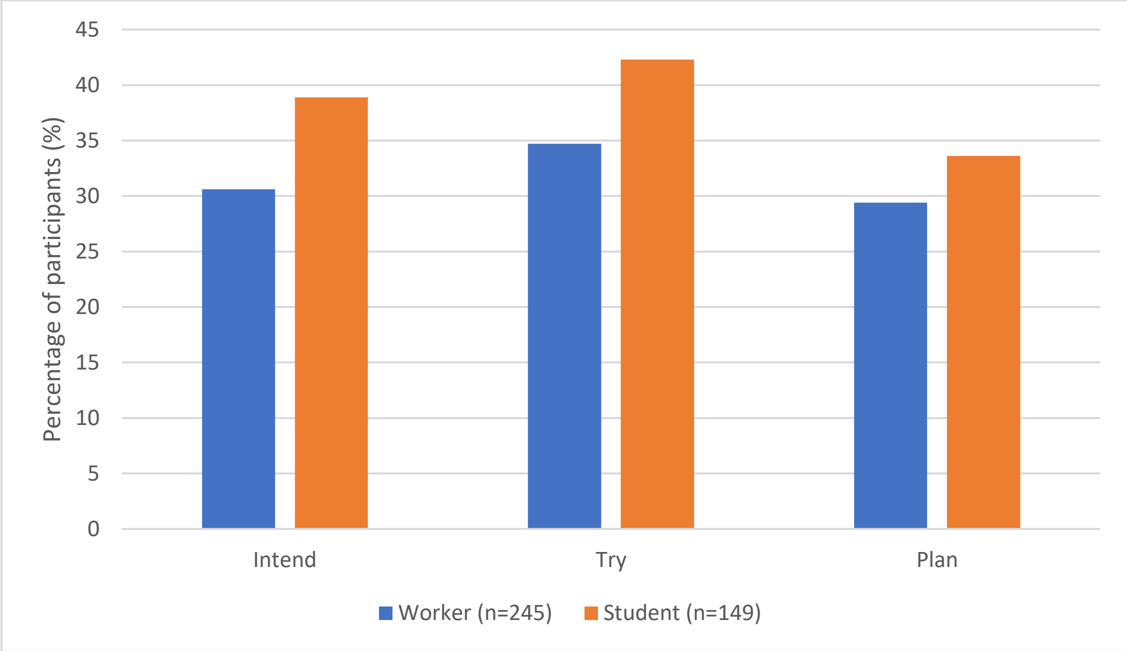


Figure 12: The percentage of participants rating their agreement to intending, trying, and planning to use public transport and shared mobility services

Following from intentions, participants were asked questions about their attitudes towards using public transport and shared mobility services using the adjectives provided in Figure 13. Mann-Whitney U tests were conducted for each adjective to compare differences between students and workers. A Mann-Whitney U test shows that there was a significant difference only for the adjectives flexible (U= 15690, p=.015) and pleasant (U=15572, p=.011). This implies both students and workers perceive the flexibility and pleasantness of using public transport and shared mobility services differently. This can be the result of students and workers having different travel needs, schedules and expectations. However, it can be argued that the familiarity students may have with using such services influences their expectations and perceptions of the service, given they do not have access to any other transport mode except for public and shared services. Nevertheless, both students and workers highly agreed on one adjective; the use of public and shared mobility benefits the environment (Students 67.8%, Workers 71.4%). The adjectives describing the use of public and shared mobility services the least for both groups were flexible (Students 42.3%, Workers 52.6%) and relaxing (Students 44.3%, Workers 47.4%).

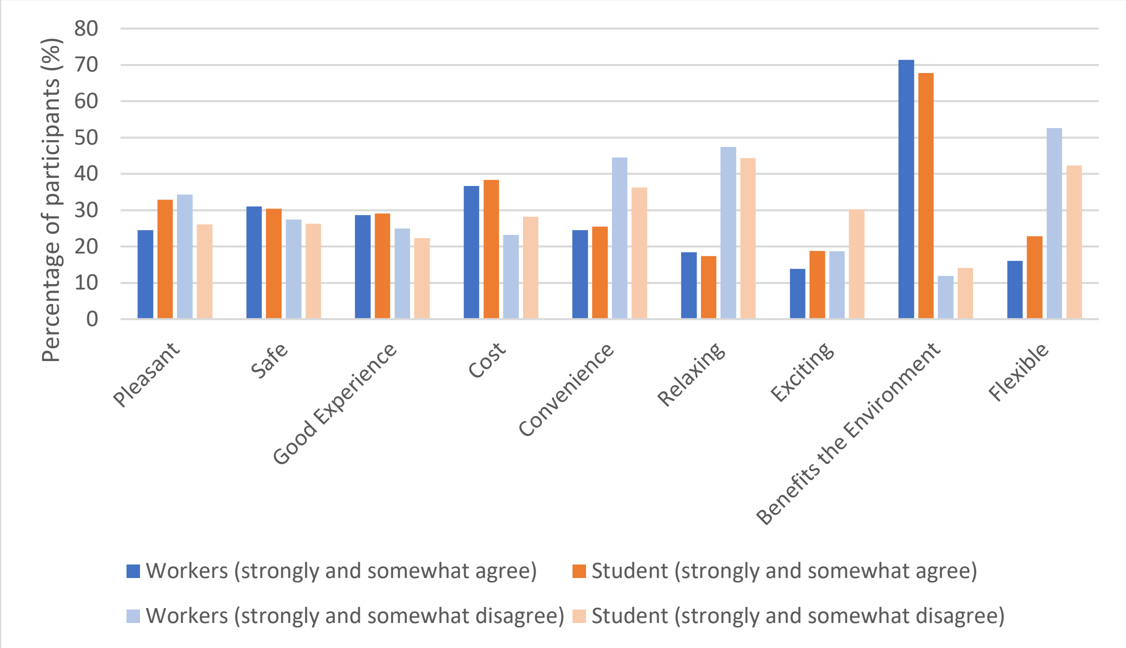


Figure 13: Levels of agreement and disagreement expressed by workers and students when using public transport and shared mobility services for their everyday trips

Following from the attitude variables, participants' answered questions related to the subjective norms. Table 15 shows the results for each statement measuring the subjective norms. A Mann-Whitney U test shows that there was a significant difference between workers and students for all responses (U= 15128, p=.003; U= 15258, p=.004; U= 15771, p=.016; U= 13260, p=.000; U= 15347, p=.006) except for "The people in my life whose opinions I value would approve of me using public and shared mobility services for my everyday trips" (U= 16941.5, p=.209). The results show student participants believe they are expected to use such services and can relate to others like them that use such services. On the contrary, workers do not believe many people like them use such services, and they do not believe they are expected to use such services. In terms of approval both students and workers believed their use of public transport and shared mobility services would be approved by the people whose opinions they value. However, students reported people whose opinions they value do make use of public transport and shared mobility services, but for the workers sample the majority claimed they do not.

Table 15: Subjective norms towards using public transport and shared mobility services for everyday trips showing the percentage of participants rating their agreement with the statements and Mann-Whitney U tests showing the significant difference for each statement between workers (W) and students (S).

Subjective norms	**SA %**	**A %**	**N %**	**D %**	**SD %**	**Mann-Whitney U test**	**Asymp. Sig (2-tailed)**
Most people who are important to me think that I should use public and shared mobility services for my everyday trips.	3.3 (W) 6.0 (S)	8.2 (W) 9.4 (S)	35.9 (W) 47.7 (S)	17.1 (W) 14.1 (S)	35.5 (W) 22.8 (S)	15128	.003
Most people who are important to me use public and shared mobility services for their everyday trips.	3.3 (W) 8.7 (S)	9.0 (W) 8.7 (S)	18.8 (W) 24.8 (S)	22.0 (W) 24.8 (S)	46.9 (W) 32.9 (S)	15258	.004
It is expected of me that I use public and shared mobility services for my everyday trips.	3.7 (W) 9.4 (S)	6.9 (W) 9.4 (S)	26.9 (W) 27.5 (S)	14.3 (W) 16.1 (S)	48.2 (W) 37.6 (S)	15771	.016
Many people like me use public and shared mobility services for their everyday trips.	5.3 (W) 15.4 (S)	13.5 (W) 22.1 (S)	22.9 (W) 22.8 (S)	19.2 (W) 18.8 (S)	39.2 (W) 20.8 (S)	13260	.000
The people in my life whose opinions I value would approve of me using public and shared mobility services for my everyday trips.	9.4 (W) 13.4 (S)	26.5 (W) 28.2 (S)	42.4 (W) 38.9 (S)	9.8 (W) 10.7 (S)	11.8 (W) 8.7 (S)	16941.5	.209
The people in my life whose opinions I value use public and shared mobility services for their everyday trips.	3.7 (W) 9.4 (S)	8.6 (W) 13.4 (S)	31.0 (W) 28.9 (S)	20.8 (W) 24.2 (S)	35.9 (W) 24.2 (S)	15347	.006

Note: SA = strongly agree; A = agree; N = neither agree nor disagree; D = disagree; SD = strongly disagree.

The final set of questions pertaining to the TPB were related to the PBC of the individual in performing the behaviour. Table 16 shows the results for each statement measuring PBC. A Mann-Whitney U test shows that there was a significant difference for the variables measuring self-efficacy ($U= 14541$, $p=.001$; $U= 15232.5$, $p=.005$) but not for the variables measuring controllability ($U= 17336.5$, $p=.392$; $U= 18201.5$, $p=.961$) between students and workers. Compared to workers, students were found to be more confident and perceived the use of shared mobility and public transport services to be easy. However, in terms of controllability, both groups agreed their use of such services was beyond their control. This meant other factors such as accessibility, finance or study and working schedules could be constraining individuals from taking a decision to use such services. Nevertheless, whether – or not – participants' use such services the majority believe the decision rests in their hands.

Table 16: Perceived behavioural control towards using public transport and shared mobility services for everyday trips showing the percentage of participants rating their agreement with the statements and Mann-Whitney U tests showing the significant difference for each statement between workers (W) and students (S).

Perceived Behavioural Control (PBC)	**SA** %	**A** %	**N** %	**D** %	**SD** %	**Mann-Whitney U test**	**Asymp. Sig (2-tailed)**
I am confident that I could use public and shared mobility services for my everyday trips if I wanted to	15.5 (W) 22.8 (S)	22.4 (W) 29.5 (S)	19.2 (W) 20.1 (S)	22.9 (W) 19.5 (S)	20.0 (W) 8.1 (S)	14541	.001
For me to use public and shared mobility services for my everyday trips would be easy	8.6 (W) 12.1 (S)	16.3 (W) 22.1 (S)	22.4 (W) 24.2 (S)	24.1 (W) 26.2 (S)	28.6 (W) 15.4 (S)	15232.5	.005
The decision to use public and shared mobility services for my everyday trips is beyond my control	21.6 (W) 20.8 (S)	22.4 (W) 22.1 (S)	26.1 (W) 20.8 (S)	19.6 (W) 22.1 (S)	10.2 (W) 14.1 (S)	17336.5	.392
Whether – or not – I use public and shared mobility services for my everyday trips is entirely up to me	35.1 (W) 36.2 (S)	26.9 (W) 28.9 (S)	18.4 (W) 11.4 (S)	13.9 (W) 12.1 (S)	5.7 (W) 11.4 (S)	18201.5	.961

Note: SA = strongly agree; A = agree; N = neither agree nor disagree; D = disagree; SD = strongly disagree.

4.2.6 Principal components analysis

Francis et al. (2004) suggests predicting intention by calculating the mean of the item scores for each of the three predictor variables, check for internal consistency and use a multiple regression procedure with intention as the dependent variable and the direct measures of attitude, subjective norms and PBC as the predictor variables. However, summated scores are a non-refined method, and an alternative is to use factor scores (DiStefano et al., 2009). Factor scores are considered as a refined computation method using a more sophisticated and technical approach that is more exact and complex than non-refined methods which then provide estimates that are standardised scores (DiStefano et al. 2009). Thus, a decision was taken to use factor scores. Factor scores are computed when performing a factor analysis (FA) which is a data reduction technique to determine whether items are measuring the same construct. Variables that are correlated with one another but largely independent of other subsets of variables are combined into factors or components (Tabachnick and Fidell, 2019). This involves a two-step procedure: extraction and rotation. Extraction is the process by which the factors underlying a collection of variables are determined. Rotation is used to simplify the structure when the extraction techniques have identified more than one factor underlying the relationships between several variables.

The most common extraction technique is the Principal Components Analysis (PCA) which is widely used in the literature using TPB (Prillwitz and Barr, 2011, Schmalfuß et al., 2017, de Oña et al., 2018, Anable, 2005). Both FA and PCA are statistical techniques applied to a single set of variables when the researcher is interested in discovering which variables in the set form coherent subsets that are relatively independent of one another. The difference between using FA and PCA is explained by Hair et al. (2014). PCA is used to summarise most of the original information in a minimum number of components for prediction purposes whereas FA is used to identify underlying factors or dimensions that reflect what the variables share in common (Hair et al., 2014). Therefore, the use of a PCA for the purposes of this study was chosen as the aim was to verify the construct validity of the direct measurements and identify the components best able to explain the chosen constructs.

As suggested by Field (2018) and Hair et al. (2014) the sequence of the main steps involved in using a PCA include:

1. Selection of dependent and independent variables: The dependent variable was intention, and the independent variables were attitudes, subjective norms and PBC. The PCA for the dependent variable was run separately from the independent variables as suggested by Hair et al. (2014).

2. Assess the suitability of data for the PCA using the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy and Bartlett's test of sphericity: For the dependent variable, the determinant of the Spearman correlations matrix was greater than the necessary value thus indicating absence of multi-collinearity, and the Bartlett's test for sphericity rejected the null hypothesis of an identity correlation matrix (p=.000). A good internal consistency with Cronbach's alpha 0.942 and good sampling adequacy with Kaiser-Meyer-Olkin (KMO) = 0.773 were found. With regards to the 19 items measuring the independent variables, the determinant of the Spearman correlations matrix was greater than the necessary value thus indicating absence of multi-collinearity, and the Bartlett's test for sphericity rejected the null hypothesis of an identity correlation matrix (p=.000). A good sampling adequacy with KMO = 0.860 and all the KMO values for individual items were found to be greater than the acceptable limit of 0.5 (Field, 2018). Hence, the KMO and Bartlett's test indicate the data for the dependent and independent variables were statistically adequate to be analysed with PCA (Field, 2018).

3. Determination of dominant components: Field (2018) suggests applying varimax rotation to identify the principal components or subsets from a dataset. Hence, Hair et al. (2014) suggests using orthogonal rotation (varimax) to avoid issues of multicollinearity when performing multiple regression. The PCA with varimax rotation was applied to the dependent variable of intention. This generated one component which was expected since the items measuring intention were taken from guidelines written by Ajzen (2006) and Francis et al. (2004). The PCA with varimax rotation was applied to the 19 items of the independent variables of attitude, subjective norms and PBC. The orthogonal rotation revealed five components as shown in Table 17, unlike the expected three components of the TPB. Five components had eigenvalues over Kaiser's (1960) criterion of 1 and, combined, explained 62% of the variance.

The expectation of running a PCA on a set of TPB questions following Ajzen (2006) and Francis et al. (2004), was of three components each representing the three variables of the TPB; attitude, subjective norms and perceived behavioural control. However, the PCA results showed five components with elements from different TPB variables forming a single component as shown in Table 17. The unexpected findings were five components with eigenvalues that exceeded 1.0 according to Kaiser's criterion. Kaiser's criterion is recommended for the situation when the number of respondents is more than 250 and the mean communality is >=0.6 (Field, 2018). Thus, the five extracted components were kept for further analysis and are shown in Table 17.

The PCA identified items that measured subjective norms with self-efficacy (Component 1) where the items demonstrated excellent internal consistency (Cronbach's alpha = 0.900). This was unexpected however, Ajzen (1991) reports how component analysis of PBC items provide clear and consistent evidence for the distinction between self-efficacy and controllability, with self-efficacy found to make significant contributions to the prediction of intentions. This is further supported by the meta-analysis conducted by Armitage and Conner (2001). The latter found self-efficacy explained more of the variance in intention than PBC did. Forward (2019) has shown how the measurement of self-efficacy was found to be one of the important factors, together with attitudes, to explain the intention of using public transport. Chowdhury and Ceder (2013) measured PBC using its constituting elements of self-efficacy and perceived controllability to investigate the role of PBC in travellers' intention to use public transport routes with transfers. Chowdhury and Ceder (2013) claim that there is sufficient clear and consistent evidence for the distinction between self-efficacy and controllability, explaining how studies exploring the dimensional structure of PBC have suggested the construct to be decomposed into: (a) self-efficacy, measured by one's confidence in ability to perform the behaviour' and (b) perceived controllability, measured by items of 'perceived control over behaviour', to improve the explanatory power of TPB. Thus, research has shown how the two-factor structure of PBC yields a significantly better fit when self-efficacy and controllability are included in the TPB model as separate latent variables rather than as the combined indicators of PBC (Ryu et al., 2003, Kraft et al., 2005). Therefore, Component 1 was labelled subjective norms and self-efficacy demonstrating how the confidence of participants' intention to use shared mobility services and public transport was also influenced by the behaviour and opinions of significant others.

The second component extracted items measuring both instrumental (flexible, convenience) and experiential (relaxing, pleasant, exciting) attitudinal items. The items demonstrated good internal consistency (Cronbach's alpha = 0.733). This meant, participants considered the use of shared mobility services and public transport for everyday trips as enjoyable and gave them control over their time by being flexible and convenient to use. Thus, Component 2 was labelled as pleasure and time sovereignty.

The third extracted component combined two items from the attitude variable measuring safety and overall good experience. The items demonstrated moderate internal consistency (Cronbach's alpha = 0.623). This meant participants valued safety and an overall good experience when using shared mobility services and public transport for everyday trips. This can be explained by the launch of an eight-week public consultation during the data collection phase, organised by Transport for West Midlands, over plans to tackle anti-social behaviour on buses to introduce bus byelaws. The main theme was centred on reducing anti-social behaviour to make bus passengers feel safer, claiming that "*fear of crime and nuisance remains a barrier, preventing many from taking the bus*"[1]. Between February and March 2019, the consultation received public feedback. If the byelaws were approved, the West Midlands would be the first region in the UK to introduce bus byelaws. Hence, the attitudinal items of safety and overall good experience loading on one component (Component 3) can be explained by participants' perception of an overall good experience was of feeling safe when using shared mobility services and public transport for their everyday trips.

The items measuring controllability for PBC were loaded on Component 4. As previously explained by Ajzen (1991), a decision can be made to aggregate overall items treating PBC as a unitary factor or to distinguish between self-efficacy and controllability. Hence, the PCA with varimax rotation separated items measuring self-efficacy from items measuring controllability. A reason for this outcome could be the one item that was measuring controllability was reverse coded. This might have caused participants to misunderstand the question. The items measuring controllability demonstrated poor internal consistency (Cronbach's alpha = 0.504). However, the result of the Item-Total correlation for this component was found to be greater than the acceptable limit of 0.3. Otherwise, if this value was less, it means that the item was not correlating very well with the scale overall (Field ,2018). Therefore, Component 4 was kept for further analysis.

The fifth component revealed the final two items for attitude measuring environmental benefit and cost of using shared mobility services and public transport. The items demonstrated a poor internal consistency (Cronbach's alpha = 0.354); however, the Item-Total correlation was lower than 0.3 implying the items were not correlating very well with the scale overall (Field, 2018). Therefore Component 5 was discarded from further analysis.

[1] See, https://www.wmca.org.uk/news/consultation-launched-over-plans-to-tackle-anti-social-behaviour-on-the-buses/

Table 17: Results of the principal components analysis with orthogonal rotation (varimax)

Items	**TPB**	**Components**					**Communalities (extraction)**
		1	**2**	**3**	4	**5**	
Many people like me use public and shared mobility services for their everyday trips.	Subjective norms	.839					.727
The people in my life whose opinions I value use public and shared mobility services for their everyday trips.	Subjective norms	.816					.679
Most people who are important to me use public and shared mobility services for their everyday trips.	Subjective norms	.801					.668
It is expected of me that I use public and shared mobility services for my everyday trips.	Subjective norms	.800					.661
Most people who are important to me think that I should use public and shared mobility services for my everyday trips.	Subjective norms	.766					.622
For me to use public and shared mobility services for my everyday trips would be easy.	PBC (self-efficacy)	.684					.701
I am confident that I could use public and shared mobility services for my everyday trips if I wanted to.	PBC (self-efficacy)	.615					.647
The people in my life whose opinions I value would approve of me using public and shared mobility services for my everyday trips.	Subjective norms	.594					.487
Relaxing	Attitude		.766				.631
Flexible	Attitude		.755				.615
Convenience	Attitude		.654				.532
Pleasant	Attitude		.606				.559
Exciting	Attitude		.521				.611

Items	**TPB**	**Components**					**Communalities (extraction)**
		1	**2**	**3**	4	**5**	
Safe	Attitude			.797			.668
Overall good experience	Attitude			.724			.625
Whether – or not – I use public and shared mobility services for my everyday trips is entirely up to me.	PBC (controllability)				.804		.656
The decision to use public and shared mobility services for my everyday trips is beyond my control.	PBC (controllability)				.749		.598
Benefits the environment	Attitude					.728	.597
Cost	Attitude					.688	.497
Eigenvalue		5.787	1.917	1.555	1.467	1.053	
Explained variance (%)		30.459	10.090	8.183	7.721	5.542	
Cronbach's alpha value		0.900	0.733	0.623	0.504	0.354	

Following the removal of Component 5 from further analysis, the PCA was rerun as suggested by Field (2018). This was done to confirm whether the structure still holds. The PCA was rerun on the remaining 17 items using varimax rotation. The KMO measure verified the sampling adequacy for the analysis KMO = 0.868 and all KMO values for individual items were above the acceptable limit of 0.5 (Kaiser and Rice, 1974). Four components had eigenvalues over Kaiser's criterion of 1 and in combination explained 61% of the variance. The items clustered on the same factors as previously shown in Table 17, thus the removal of the attitude variables loading on Component 5, did not alter the position of the other variables in relation to their previous component load.

As a result of the PCA, standardised factor scores were extracted. The extracted factor scores for each of the four components were continuous data and hence Pearson's correlation coefficient was used to assess the strength of the relationship between the four extracted components and intention.

4.2.7 Correlation and linear regression analysis

For both the worker and student sample three out of the four extracted components were found to be correlated with intention (Table 18). Controllability was not found to correlate significantly with intention (Student r=-.100, p=.229, Workers r=.097, p=.131). Thus, the component for controllability was not expected to perform well in the linear regression analysis.

Table 18: Pearson correlation coefficients using the four extracted components from the PCA with intention

Extracted components from PCA	Worker	Student
1 - Subjective norms and Self-Efficacy	r=.609, p<0.01	r=.506, p<0.01
2 - Pleasure and Time Sovereignty	r=.354, p<0.01	r=.180, p<0.05
3 - Safety and overall good experience	r=.196, p<0.01	r=.294, p<0.01
4 - Controllability	r=.097, p=.131	r=-.100, p=.229

A linear regression model was computed to include the four components and predict the intention of using public transport and shared mobility services by workers (Table 19) and students (Table 20). As discussed previously, both workers and students have different mobility resources and constraints and therefore separate results and analysis are provided. However, results are compared between students and workers to identify any differences or similarities in their intention to use public transport and shared mobility services. For instance, both samples recorded subjective norms and self-efficacy to be the strongest predictors of intention. This was followed by attitudes measuring pleasure and time sovereignty, and safety and an overall good experience. Therefore, the significant predictors for both workers and students were in line with the hypotheses for attitudes, subjective norms, and self-efficacy in relation to behavioural intention (Chapter 3, Section 3.2.2). However, the PBC construct of controllability was not found to be a significant predictor of behavioural intention for both workers and students.

Table 19: Summary of linear regression analysis using the extracted components of the TPB to predict intention for the worker sample

Predictor	B	Standard Error	Beta	t	Sig.
Constant	.027	.045		.598	.550
Subjective norms and Self-Efficacy	.616	.046	.602	13.446	.000
Pleasure and Time Sovereignty	.299	.045	.298	6.662	.000
Safety and overall good experience	.246	.046	.240	5.382	.000
Controllability	.055	.046	.053	1.196	.233

Note: n=245, R^2 = .517; F (4) 66.334, p<0.001

Table 20: Summary of linear regression analysis using the extracted components of the TPB to predict intention using the student sample

Predictor	B	Standard Error	Beta	t	Sig.
Constant	.053	.067		.796	.427
Subjective norms and Self-Efficacy	.512	.066	.518	7.723	.000
Pleasure and Time Sovereignty	.253	.065	.260	3.882	.000
Safety and overall good experience	.221	.062	.235	3.545	.001
Controllability	-.042	.062	-.045	-.675	.501

Note: n=149, R^2 = .365; F (4) 22.128, p<0.001

Reasons for the construct of controllability being an insignificant predictor for intention could be the interpretation of the question. Therefore, an alternative approach was needed to measure controllability given the items measuring controllability were poor predictors. However, this result can be due to the strong influences from the subjective norms and attitudes for which Ajzen (1991) explains such strong influences can lead to PBC being less predictive of intentions (Armitage and Conner, 2001). Ajzen (1991) argues the magnitude of the PBC-intention relationship is dependent upon the type of behaviour and the nature of the situation. Armitage and Conner (2001) explain the implementation of an intention into action is at least partially determined by personal and environmental barriers, hence other factors that can act as alternative measures to perceived controllability were tested; these included available resources and opportunities (Armitage and Conner, 1999, Terry and O'Leary, 1995).

4.2.8 Alternative controllability measures

Alternative measures of controllability were elicited from Hägerstrand (1970) time-geographic mobility constraints. These included mobility difficulty, commute distance, available public transport services close to home and mobility tools (driving licence, car ownership, public transport subscription). These alternative measures represent mobility constraints and resources which have control over the performance of the behaviour. Alternative measures considered to positively influence control over using public and shared mobility services, included available public transport services close to home and the possession of mobility tools. Having a public transport service available close to home gives control and access over to the participant to use such transport modes. Mobility tools provide the participant with the resources and therefore control over which transport modes to use. Alternative measures considered to negatively influence control included having mobility difficulties in terms of long term physical or health issues and the commute distance. Having mobility difficulties reduces the control a participant has when using certain types of transport modes. Commute distance influences the type of transport mode that can be used to commute.

For both the student and workers sample, a point bi-serial correlation was carried out to assess the relationship between the alternative measures of controllability and the PBC measure for controllability (Table 21). For the workers sample the highest correlation coefficient was public transport access close to home, followed by not having mobility difficulties and commuting a short distance. For the student sample the highest correlation coefficient was not having mobility difficulties followed by commuting a short distance. The other variables were not found to correlate with the PBC measures for controllability.

Table 21: A point bi-serial correlation was used to measure the strength and direction of the association between the TPB measure for controllability and the chosen alternative measures for controllability

Alternative controllability predictors	Worker	Student
Mobility difficulties (0=no, 1=yes)	r=-.217, p=.001	r= -.249, p=.003
Commute distance (continuous)	r=-.216, p=.001	r=-.218, p=.011
Available public transport services close to home (0=no, 1=yes)	r = .220, p=.001	r=.097, p=.251

For both the worker (Table 22) and student samples (Table 23) none of the controllability predictors were significant. Therefore, the results imply other factors might be more suitable to measure controllability and predict intention. Nevertheless, it is important to note that Ajzen (1991) found controllability to significantly predict behaviour but not to predict intentions. Thus, the role of controllability could be in predicting participants' behaviour.

Table 22: Summary of linear regression analysis using the extracted components of the TPB, including items representing controllability, to predict intention using the participants in the worker sample

Predictor	B	Standard Error	Beta	t	Sig.
Constant	-.020	.167		-.120	.905
Subjective norms and Self-Efficacy	.636	.049	.608	13.054	.000
Pleasure and Time Sovereignty	.315	.049	.302	6.442	.000
Safety and overall good experience	.283	.049	.268	5.804	.000
Commute Distance (continuous)	.003	.005	.032	.674	.501
Available public transport services close to home (0=no, 1=yes)	.013	.158	.004	.082	.935
Mobility difficulties (0=no, 1=yes)	.126	.165	.036	.762	.447

Note: n=228, R^2 = .525; F (6) 42.802, p<0.001

Table 23: Summary of linear regression analysis using the original variables of the TPB, including items representing controllability, to predict intention using the participants in the student sample

Predictor	B	Standard Error	Beta	t	Sig.
Constant	-.006	.085		-.066	.948
Subjective norms and Self-Efficacy	.503	.072	.501	6.986	.000
Pleasure and Time Sovereignty	.274	.070	.281	3.924	.000
Safety and overall good experience	.250	.072	.253	3.466	.001
Commute Distance (continuous)	.003	.004	.057	.808	.420
Mobility difficulties (0=no, 1=yes)	.225	.318	.051	.708	.480

Note: n=131, R^2 = .366; F (5) 16.02, p<0.001

4.3 Discussion

To predict the intention of using MaaS, this study focused on predicting participants' intention to use public transport, bike sharing, carsharing and ridesharing services. This was done using the predicting variables of intention found in the TPB. In addition, worker and student participants were examined for their multimodal travel behaviour characteristics. This was done following the belief of experts that potential early adopters of MaaS would be public transport users and flexible travellers (Jittrapirom et al., 2020).

Students and workers using two or more transport modes (excluding walking) within a week were labelled multimodal. Given the study context of Birmingham is densely populated (ONS, 2020) and has a dense railway network and bus service operated by Transport for West Midlands, it was assumed to offer travellers the opportunity to be multimodal. This is consistent with Heinen (2018) who argued how various studies have investigated the predictors of modal variability and overall multimodality was found to be more prevalent in areas with higher population densities. However, only less than half of the worker and student samples were found to be multimodal, therefore the characteristics of multimodal workers and students was examined in comparison to non-multimodal travellers.

Many studies on multimodality have focused on building a characteristic profile of the user using travel behaviour and sociodemographic variables. Both students and workers were found to have unique travel needs and challenges (Moniruzzaman and Farber, 2018). This difference was found to influence the likelihood for both groups to be multimodal travellers. Multimodal workers were found to combine their use of private car with public transport, whereas students switched between public transport modes considering mostly were not car owners (Nobis, 2007).

A number of factors used by Heinen and Chatterjee (2015) were tested with the prospect of explaining multimodality for students and workers. None of the variables were found to distinguish multimodal from non-multimodal students. This was explained by the homogenous characteristics of age, mobility tool ownership and commute distance of this sample, making it difficult to predict students who are multimodal based on sociodemographic and travel behaviour variables alone. Therefore, other factors would need to be identified to explain multimodal travel behaviours by students. As for the worker sample, multimodal participants were young, engaged in full-time employment and commute 13 miles or less. This was not surprising given how young adults who have graduated from university would be more open to use different transport modes in addition to their private car. This is consistent with Buehler and Hamre (2015) who found higher levels of multimodal car use among individuals with a higher level of education. In addition, the commute distance of 13 miles or less indicates the dense transport network available within that radius and being employed full-time provides the financial means to support the use of more than one transport mode. Despite their differences, an unexpected result for both workers and students was the negative coefficient of rail card subscription predicting multimodal travel behaviour. Although the result for both groups was insignificant, the negative coefficient meant rail users were less likely to be multimodal and therefore their first and last mile was by walk. This was found to be plausible given the dense network of rail stations across the city of Birmingham.

When students and workers were asked whether they would likely try MaaS before deciding to commit to it or not, a Mann-Whitney U test shows that there was a significant difference between students and workers ($U=10102.5$, $p=.001$). Students reported to be more likely than workers to try MaaS. This can be partially explained by studies that show young adults to be more open to use different transport modes compared to older adults (Jamal and Newbold, 2020, Kuhnimhof et al., 2012b, Nobis, 2007). However, the lack of interest from the workers sample can be attributed to most of them being car drivers with a commitment to use their car. The commitment with car use relates to high costs and so, as explained by Simma and Axhausen (2001), travellers trade large one-off payments for low or zero marginal cost at the point of use. Therefore, workers who are committed to driving their car would be less likely to try MaaS. Nevertheless, the role of MaaS among car owners was studied in an exploratory MaaS pilot by Storme et al. (2020). The results of the MaaS pilot found MaaS to mainly complement car ownership and car use.

After determining the factors explaining multimodal travel behaviours for workers and students, the factors predicting intention to use public transport, bike sharing, carsharing and ridesharing services for everyday trips was examined. Predicting the intention to use these services served to explore which factors would influence the uptake of MaaS. The variables of attitude, subjective norms and PBC were used as predictors for intention as established by the TPB. The unexpected result of the constructs after performing a PCA led to an understanding of which factors would be important in predicting intention for workers and students commuting in Birmingham. Overall, subjective norms and self-efficacy, pleasure and time sovereignty and safety and an overall good experience were significant predictors of intention for both workers and students. The strongest predictor was subjective norms and self-efficacy. This suggests participants intend to use public transport and shared mobility services depending on their confidence and how easy or difficult the task would be, as well as what the behaviours and opinions of their significant others would be. Thus, Phithakkitnukoon et al. (2017) observed how the likelihood of choosing either public transport or driving as a commute mode choice increased with the portion of social ties choosing that particular mode. The social expectation on intention to use public transport was found for a group of commuters in the UK by Donald et al. (2014). This means if a person lives in a community which supports public transport, they will have a greater tendency to use it (Fu and Juan, 2017). Hence, social network evidently does influence transport mode choice.

The coupling of instrumental (flexible, convenience) and experiential (relaxing, pleasant, exciting) attitudes as significant predictors of intention for both the worker and student sample, highlights how pleasure and convenience are important attributes in mode choice.

Being able to enjoy riding public transport and shared mobility services combined with the flexibility and convenience increased participants' intention to use such services. This is linked to the main objective of MaaS, which aims to reduce car dependency by providing flexible and customised subscription plans using different transport modes. With regards to the pleasure and convenience of using public transport and shared services, these are explained by the quality of the transport services. Ambak et al. (2016) found how transport quality which consists of performance measures and service measures such as how the customer perceives the service, was significant in influencing the intention of the user to use the public bus.

The quality of the public transport and shared mobility services were perceived differently by students and workers. The fact that students are limited in their choice of transport modes due to the lack of car ownership and financial resources, their expectation of public transport services to be pleasurable and convenient would be lower compared to workers. Nevertheless, students have more opportunities to make use of such services due to student discount rates and university campuses being well served by the public transport network. As argued by Busch-Geertsema and Lanzendorf (2017) students have less money available or do not want to spend it on owning or operating a car. Therefore, students choose to live in urban settings with high levels of accessibility by public transport and non-motorised modes in order to meet their travel needs.

On the other hand, workers have a wider choice of transport modes with the inclusion of car ownership and economic freedom to choose whichever transport mode they wish (Heinen and Chatterjee, 2015). Indeed, in this study 75.5% of the workers who have a public transport subscription also own a car. Pleasure of using shared mobility services and public transport for workers can be the result of not having to drive and deal with the traffic, while the convenience may lie in the fact of not having to look for a parking space when commuting by car – or not – having to walk far from work or home to their parking space (Christiansen et al., 2017). Convenience may also be access to a public transport service close to the place of work, hence most of the worker sample reported to live and work within walking distance of a public transport service with a frequency of more than once an hour. Therefore, good access to a public transport service close to the place of work, with a good frequency and having a pleasurable experience, can lead to workers opting for such services even when there is a car available. Hence, Kuhnimhof et al. (2006) explained how workers opt for public transport services in specific situations because it is the better option and not because there is no car available.

The third significant predictor of intention for both students and workers, was the combined measures of safety and overall good experience. This unexpected result of having safety and overall good experience extracted as a combined component and not loading with the other attitude variables, was explained by the public transport campaign carried out during the data collection phase. Transport for West Midlands launched a public consultation over plans to tackle anti-social behaviour on buses to introduce bus byelaws. This shows how bus users were experiencing social discomfort when using bus services in the West Midlands. The consultation had received an overwhelming response and a list of the bus byelaws were published in August 2021. Following a 30-day period, the byelaws would then be implemented. The proposed byelaws apply to bus stations, bus shelters and bus stops. Therefore, the overall good experience can be explained by the perceived accessibility of a transport mode as being safe. Friman et al. (2020) explains safety in terms of injuries related to the infrastructure such as stairs, platforms or ramps, violent crime such as thefts and knife attacks, non-violent crime such as anti-social behaviour and drunkenness, or even infections and viruses. These are hazards which travellers would not want to experience when using public transport or shared mobility services. In their study, Friman et al. (2020) found public transport travellers from five northern European cities to be concerned about their safety on public transport. In addition, Cruikshanks et al. (2013) found ride share initiatives to prove difficult to operationalise in the UK due to the safety concerns of travelling with strangers. Hence, the attitudinal items of safety and overall good experience loading on one factor explains participants importance of having an overall safe journey when using public transport and shared mobility services for their everyday trips.

Both workers (62%, n=245) and students (65.1%, n=149) believe that it is up to them to decide whether they use shared mobility services and public transport. However, both groups (workers 44% n=245, students 42.9%, n=149) believe there are factors which hinder them from using such services. The items measuring controllability loaded together to form a component from the PCA, but the component was not found to be a significant predictor of intention with a weak correlation of r=0.01 (p=0.71). The reason for this weakness can be attributed to how PBC has a second role in the TPB model explaining the relationship between intention and behaviour. The TPB is an extension of the TRA which introduces PBC as a third determinant of intention and behaviour. The theory contends that people who intend to perform a specific behaviour may not necessarily have volitional control over that behaviour; the absence of volitional control may be caused by the presence of behavioural control that impedes the actual performance of that behaviour (Ajzen, 2020). Ajzen (2020) argues "*When people have perfect volitional control over the behaviour of interest and when they strongly believe that* *they are capable of performing the behaviour if they so desire, behavioural control is irrelevant*". Thus, in this study PBC self-efficacy results show both students and workers have strong beliefs of performing – or not – performing the behaviour. Students were found to be confident to perform the behaviour and found it easy for them to use shared mobility and public transport services. Workers were found not to be confident in using such services and reported that they do not find it easy using such services, therefore they might show no desire to perform the behaviour. When this happens the TPB is reduced to the TRA (Ajzen, 2020).

4.4 Limitations and further research

Several limitations have been found when setting up and implementing this study. The income per household unit and number of young children in the household were not measured and could have had an impact on describing multimodal travel behaviour and participants' intention to use public transport and shared mobility services (Nobis, 2007, Buehler and Hamre, 2015).

Another limitation was the target behaviour which included both public transport and shared mobility services. The availability of public transport can be considered more accessible and comprehensible for participants compared to shared mobility services such as carsharing, ridesharing and bike sharing. Despite each shared mobility service was defined, the level of comprehension by participants was unknown. Moreover, the target behaviour encompassed travel for everyday trips including commuting and leisure activities and research has shown how travellers use different transport modes for different purposes. Therefore, if the target behaviour was narrowed down to a trip purpose the results would have been different. The reason for presenting a target behaviour that encompassed all types of travel activities was to mimic how a MaaS subscription can be used for all types of travel purposes. Nevertheless, research has shown how the users are the main actors in the MaaS ecosystem and tailored mobility packages are required to serve different targeted groups in accordance with their age, travel purpose and travel behaviour (Arias-Molinares and García-Palomares, 2020). Different users may have different requirements as business travellers, for example, may value time and service reliability whereas students may be sensitive to cost and social/environmental qualities of shared mobility services (Arias-Molinares and García-Palomares, 2020).

Chapter 5 Commuters' Preference for MaaS

Chapter 4 results show which psychological factors influenced commuters' intention to use public transport and shared mobility services. This chapter examines the potential uptake of MaaS according to participants' sensitivities to travel mode attributes. To analyse commuters' preference for MaaS, this chapter outlines the methodology used in Section 5.1, followed by a detailed results and analysis (Section 5.2). This chapter ends with the discussion of the results (Section 5.3) and conclusion (Section 5.4).

The aim of this chapter was to evaluate the potential demand for MaaS in the West Midlands with other currently available transport modes in the market. The research question for this chapter was:

- **RQ2**: What is the appeal of MaaS?

To answer RQ2 the following objectives were used:

(1) Identify the transport modes preferred by commuters when given the choice of MaaS.

(2) Identify the importance and intensity of attributes influencing mode choice.

(3) Examine which sociodemographic and travel characteristics define the choice of certain transport modes over others.

5.1 Methodology

5.1.1 Discrete choice experiment

As explained in Chapter 3 a DCE (Ben-Akiva and Lerman, 1985) was chosen to determine commuters' preference for MaaS among a set of currently existing travel subscriptions and the private car. DCEs involve three main inter-related components: (i) an experimental design used to implement the choice survey and generate choice data; (ii) discrete choice analysis to estimate preferences from the choice data; and (iii) use of the resulting model to derive welfare measures and conduct other policy analyses (Lancsar and Louviere, 2008). The process to design the DCE was supported by expert guidance, several choice analysis textbooks and articles detailing the steps to design the experiment (see De Dios Ortúzar and Willumsen 2011, Hensher et al., 2005, Hess and Rose, 2009, Weber 2019, Johnson et al., 2013).

For this study, a stated choice experiment was used because the scenario chosen for the experiment was hypothetical (Yan et al., 2019). In creating a stated choice experiment, Bliemer and Rose (2009) list three main steps which must be followed. The first step is a complete model specification with all parameters to be estimated. Based on this model specification, an experimental design type is selected and then the design can be generated as the second step. The third and final step is the creation of the questionnaire based on the underlying experimental design, and data can be collected. However, prior to estimating the parameters, the alternatives, attributes, and attribute levels need to be available to be entered into the model. Figure 1 provides the key stages taken to design and construct the DCE survey. The following section explains each step taken for the stated choice experiment for this study.

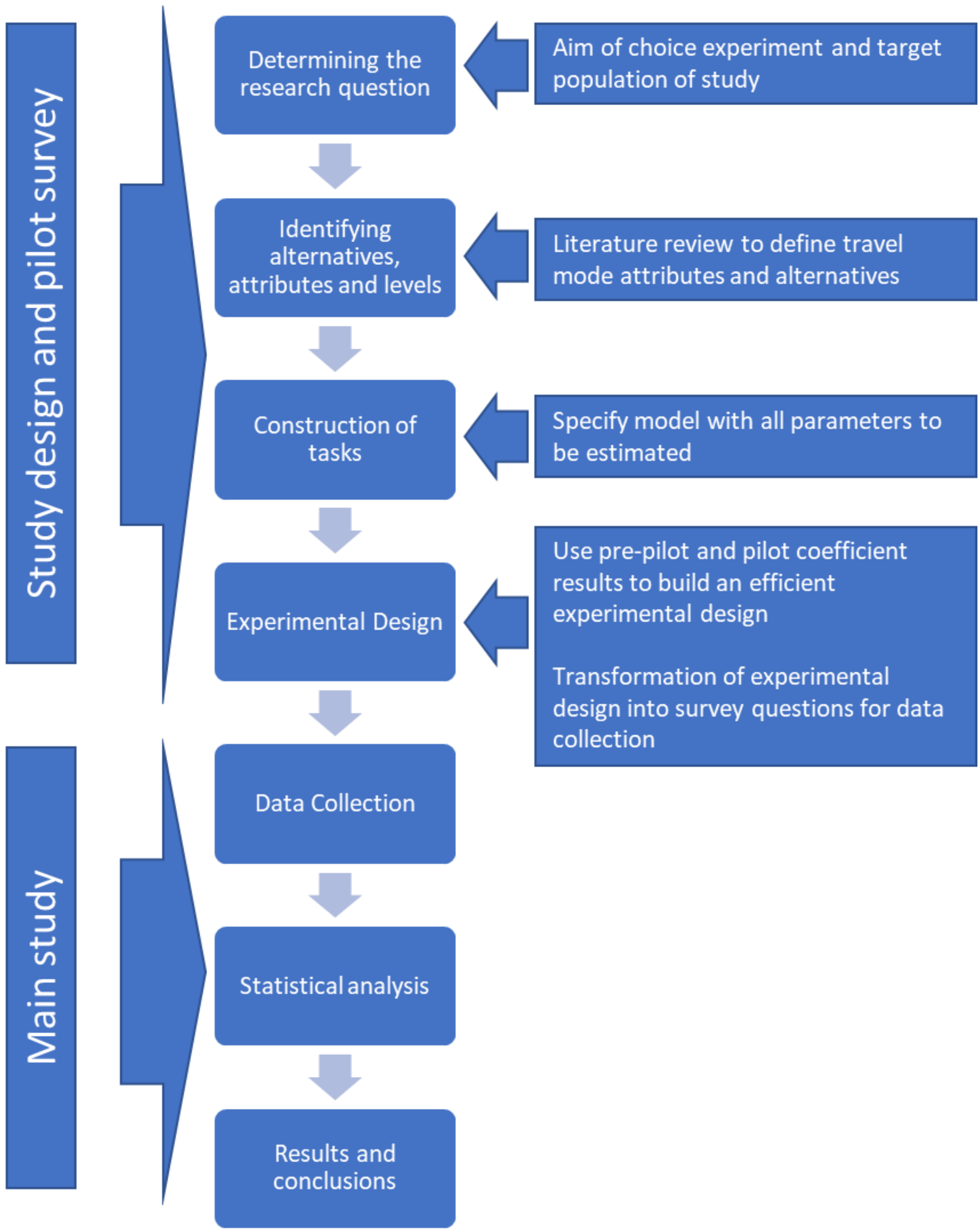


Figure 14: The steps involved in designing a choice experiment

5.1.2 Determining the research question

The purpose of the choice experiment was to determine commuters' preference for MaaS among a set of currently existing travel subscriptions and the private car. De Dios Ortúzar and Willumsen (2011) suggest researchers to start by identifying the population of interest and the alternatives to be studied. As explained in Chapter 3 (Section 3.2.1) the target sample population were full-time students and employed, or self-employed workers located in the West Midlands. Participants were presented with several choice tasks each consisting of alternatives and asked to indicate which alternative they preferred in each choice task (Hensher et al., 2005) by means of a trade-off process (Bliemer and Rose, 2011). The alternatives chosen were existing transport modes and each alternative was characterised by attributes which influenced the utility of the transport modes (Yan et al., 2019). The statistical analysis of responses allowed for the estimation of participants' sensitivities to the various attributes (Scuttari et al., 2019).

5.1.3 Identifying the alternatives

The number of alternatives in a DCE has a large influence on error variance, with four alternatives being superior to three or five in terms of scale effects (Caussade et al., 2005). Nevertheless, more alternatives increase the cognitive burden on participants. However, Hensher (2006) emphasised that relevance of alternatives is more important than trying to limit cognitive burden.

Using the results of the TPB in Chapter 4, the private car, bus, and train were the three most used transport modes for commuting purposes. Thus, the selected alternatives competing with a monthly MaaS plan were the private car, a monthly bus pass and a monthly train pass. This served the aim of this study, which aimed to investigate commuters' preference for a monthly MaaS plan when given the choice of other conventional available transport modes. Each alternative in the choice task varied according to their travel mode attributes which are discussed in the following sections.

5.1.4 Defining attributes and levels

Attributes can be quantitative (e.g., waiting time) or qualitative (e.g., crowdedness) and are generally identified from literature, qualitative research with samples of relevant participants and experts (Lancsar and Louviere, 2008). The attributes used in this study to describe the alternatives were selected based on literature review and experts' opinions. The number of attributes chosen for the study were carefully selected since the greater the number of attributes, the greater the cognitive difficulty of completing a choice experiment (Matyas and Kamargianni, 2019).

The appropriate selection of attributes and attribute levels led to the construction of alternatives that were meaningful and realistic for the participant (Hensher et al, 2003; Louviere et al., 2000, Cherchi and Hensher, 2015, Weber 2019). In the absence of DCE studies on MaaS as an alternative option, attribute selection started from a literature review of the existing studies on mode choice using conventional or innovative transport technologies (Chapter 2 Section 2.1.3).

Based on the literature review, the four attributes that significantly affected mode choice were the cost of the journey, in-vehicle time, walking time and waiting time. Given that MaaS is defined as a monthly subscription plan, the other conventional transport modes of the private car, bus and train were also defined as monthly plans in terms of cost. Hörcher and Graham (2020) argued how mobility packages in the form of subscriptions resemble the commitment car owners have towards car use. Thus, the private car was given a monthly cost to allow participants to compare between alternatives. With regards to the attributes, in-vehicle time, walking time and waiting time, these were defined as minutes taken for each commute journey done by the respective alternative. Each attribute level was determined using available literature and information accessible via the web noting the prices and timings at the current time of creating the experimental design.

Many more attributes could be used to explain transport choices, including those that were not easily quantifiable, such as travel time uncertainty and the level of crowding on a public transport vehicle. However, Johnston et al. (2017) recommends avoiding imprecise or qualitative terms such as “high”, “medium” and “low” unless these terms are clearly defined and understood by participants. Hence, such qualitative terms were excluded from this study.

The number of allowed attribute levels is discussed in De Dios Ortúzar and Willumsen (2011) suggesting that the more levels used, the higher the potential number of choice tasks required due to additional parameters being estimated. Similarly, the uneven number of attribute levels for different attributes may also yield a higher number of choice tasks due to attribute level balance. To avoid uneven number of attribute levels and to provide a sensible number of attribute levels, four attribute levels per attribute were used. With regards to varying the range of attributes, De Dios Ortúzar and Willumsen (2011) and ChoiceMetrics (2018) suggest using a wide range for statistical purposes however this might result in choice tasks with dominated alternatives. Wide range is defined as e.g., £1-£6 which is statistically preferable compared to using a narrow range e.g., £3-£4 as the former will theoretically lead to better parameter estimates (Choice Metrics, 2018). Nevertheless, there is a trade-off between the statistical preference for a wider attribute level range and the practical considerations that may limit this range (De Dios Ortúzar and Willumsen, 2011, Choice Metrics, 2018).

The following paragraphs discuss each attribute in more detail and provide an explanation on the process of choosing the attribute levels.

Monthly cost

The monthly cost proved to be challenging to calculate for the car alternative with most of the mode choice studies calculating car cost using fuel cost per kilometre. Research shows the costs of running a car are made up of fixed annual costs, sporadic costs, fuel costs and depreciation (Chatterton et al., 2018). Chatterton et al. (2018) argued how difficult it was to calculate the full costs of car ownership. Thus, the authors opted to assess motoring costs specifically by using vehicle excise duty and road fuel costs as these were considered inflexible and most directly influenced by taxation policy.

To measure car costs, data from the Office of National Statistics (ONS) was considered. The available data on monthly car expenditure in the UK shows household expenditure on motoring for households owning a car, segmented by disposable income decile group (ONS, 2019). Deciles are the income values which divide the UK population. The figures reported by the ONS covered the period between 1 April 2018 to 31 March 2019 (as at the time of setting up the experimental design). The average weekly household expenditure was shown for three services, the purchase of vehicles, the operation of personal transport, and licences, fines, and transfers. In this study, the purchase of vehicles was not considered as this was highly subjective and varied, thus the cost of the monthly car was based on the running costs of owning a car. Calculating the average weekly expenditure of the operation of personal transport and licences, fines, and transfers for all households across all decile groups, the total came to £49 per week totalling to £196 over 4 weeks.

Schikofsky et al. (2020) argued that in our fast-moving times, individuals often base their decisions on imperfect information because individuals often do not have all the information needed to completely understand new products and technologies. Therefore, after performing an internet search on the average monthly expenditure of a UK motorist, a report by the company Kwik Fit (2018) was reported by several press articles. Kwik Fit is one of the largest independent automotive parts, repair, and replacement specialist company with over 600 service centres across the UK including the West Midlands. Kwik Fit can be considered as a reliable professional car service with a high number of stations in the West Midlands after

London. Table 24 shows the average monthly spend broken down into different expenses related to running a car as reported by the company Kwik Fit. The value of £162 a month was used as a reliable average monthly car running cost after being compared to the ONS value. Moreover, the average monthly cost for the car was evaluated carefully since if the cost of the private car was too high in comparison with the other transport options, there would not be any trade-off between the alternatives.

Table 24: The average monthly costs of running a car broken down into different items (Kwik Fit, 2018)

Item	**Average Monthly Spend**
Fuel	£67.63
Car insurance	£31.64
Routine maintenance and servicing	£15.96
Unexpected repairs and breakdowns	£13.26
Vehicle excise duty (road tax)	£12.16
Breakdown cover	£6.96
Parking permits and tickets	£6.89
Cleaning	£4.15
Fines	£3.69
Monthly average total (excluding finance)	**£162.33**
Finance	£226.12
Monthly average total (including finance payments)	£388.45

The bus and train monthly costs were estimated using the Network for West Midlands website that is available for residents to buy monthly travel plans for the bus, train, and metro services. The cost for taking the bus or train anytime of the day and for all the areas covered in the West Midlands were £64 and £74.60, respectively. These values were used as an average cost on which to calculate the other three levels needed for the attribute.

The average monthly cost for a MaaS subscription was taken from the brief launch of the MaaS app Whim in the West Midlands by Transport for West Midlands. The service had three options (1) pay-as-you-go (2) Whim every day for £99 per month including unlimited public transport with taxis and best-price car hire and (3) Whim unlimited for £349 per month which included unlimited public transport, all taxi rides within a three-mile radius of the user's location and up to 30 days car hire per month. The monthly cost of £99 was considered reasonable and competitive in comparison to the other alternative transport modes used in this study.

Using the average monthly cost values for each alternative as shown in Table 25, three attribute levels were estimated from the average monthly cost value using percentages to increase and decrease the current value. Several studies created attribute levels using ranges from ±10% to ±50% of the current values (Espino et al., 2007, Rojo et al., 2012, Ciari and Axhausen, 2012). In this study an increase of 10% and a reduction of 10% and 20% on the average monthly value for each alternative was used.

Table 25: Actual monthly cost of each alternative

Alternative	Definition	Price as at end of May 2020	Source
Car	Costs of running and maintain the vehicle excluding the purchase of the vehicle.	£162.00	Kwik Fit car servicing and repair company in the UK
Bus	Monthly Swift Pass unlimited travel on all buses (approved operators), all day in the Network West Midlands area.	£64.00	Network West Midlands
Train	Anytime unlimited train travel to Zones 1-5 within the West Midlands.	£74.60	Network West Midlands
MaaS	Unlimited travel by bus, train and tram including taxi and car rental service discounts.	£99.00	MaaS Global Whim app

In-vehicle time, walking time and waiting time

In this study, the total travel time of a journey was defined using three different attributes (Schubert et al., 2020, Cox, 2015). Arentze and Molin (2013) conducted a meta-analysis of studies on time and service quality valuations of travellers in the British context and found travellers valued different travel time components: in-vehicle time, walk time, access time, wait time, search time and delay time in public and private transport contexts. Thus, for this study the total travel time was divided between in-vehicle time, walking time, and waiting time.

The attribute levels for in-vehicle time, defined as the average time taken inside a transport mode, were estimated on the hypothetical scenario. The hypothetical scenario asked participants to assume that they lived 7 miles away from Birmingham City Centre to which they had to commute. Google Maps API was used to estimate realistic driving times and journey times by bus and train within 7 miles and for walking distances to nearby bus stops and train stations (Frei et al., 2017, Danaf et al., 2019). In a statement by Transport for West Midlands (2020), the desirable walking distance to bus services in continuously built-up residential areas was 400 metres and in less densely populated areas 700 metres. Thus, both measurements were used to estimate walking times.

The attribute levels chosen for waiting time were inspired by other mode choice studies. The waiting time for the private car was null (Stoiber et al., 2019, Frei et al., 2017), while the waiting time for the bus, train and MaaS, were estimated using the waiting time attribute levels found in other mode choice experiments (Stoiber et al., 2019, Ciari and Axhausen, 2012, Liu et al., 2019, Catalano et al., 2008, Arentze and Molin, 2013, Belgiawan et al., 2017). The waiting time was defined as the average time taken from the instant an individual arrives at a bus stop or station and wait until the next scheduled departure.

Table 26 shows the complete set of alternatives, attributes and attribute levels used in the experimental design. Once the alternatives and the range of the attribute levels were finalised, the next step in the design of the DCE was to generate the choice tasks using an experimental design strategy.

Table 26: Alternatives and attribute levels used in the choice experiment

Attributes / Alternatives	**Monthly Cost** **Car –**Cost of running a car (not including the cost of the car itself) **Bus, Train, MaaS –** Monthly subscription	**In vehicle Time (minutes) per commute trip** (Average time taken inside a transport mode)	**Walking Time (minutes) per commute trip** (Average time taken to walk to a public transport stop or to the car)	**Waiting Time (minutes) per commute trip** (Average time taken from the instant you arrive at a stop or station and wait until the next scheduled departure)
Car – use of a private car	£130, £145, £162, £178	20, 25, 30, 35	0, 3, 6, 9	0
Bus – Anytime and unlimited use across the West Midlands	£51, £57, £64, £70	30, 35, 40, 45	4, 6, 8, 10	3, 6, 9, 12
Train – Anytime and unlimited use within the specified Rail Zones 1 to 5	£60, £67, £75, £82	20, 25, 30, 35	6, 9, 12, 15	3, 6, 9, 12
MaaS – Anytime and unlimited use of bus, tram, train within zones 1 to 5 and discounted taxi and car hire	£80, £90, £100, £110	20, 25, 30, 35	6, 9, 12, 15	0, 3, 6, 9

5.1.5 Experimental design

As explained by Bliemer and Rose (2011), while information related to which alternatives, attributes, and attribute levels to use may come from secondary data sources or qualitative research, the precise method used to construct the underlying experimental design remains solely at the discretion of the researcher. Little guidance exists as to which method to select when generating an experimental design for DCE studies (Bliemer and Rose, 2011). For this study, reliable literature, and expert consultations in the field of DCEs provided guidance on constructing the choice tasks and experimental design (example Ferrini and Scarpa, 2007, De Dios Ortúzar and Willumsen, 2011, Choice Metrics, 2018). As a definition, an experimental design describes the hypothetical choice situations composed of possible combinations of attribute levels and is presented to participants in the form of choice tasks (Choice Metrics, 2018).

Type of experimental design used

The experimental design in this study was a labelled experiment since the chosen alternatives represented specific transport modes. The orthogonal design has been widely used in stated choice experimental design methods. However, efficient designs have been empirically shown to have smaller standard errors in model estimation at smaller sample sizes compared to orthogonal designs (Ferrini and Scarpa, 2007, Bliemer and Rose, 2010, Bliemer and Rose, 2011, Bliemer et al, 2008, Rose and Bliemer, 2013, Choice Metrics, 2018). Thus, researchers found efficient designs to be able to produce more efficient data with more reliable parameter estimates that can be achieved with an equal or lower sample size (Rose and Bliemer, 2009). Therefore, the type of experimental design used for this study was an efficient design. However, to proceed with using an efficient design, prior parameter estimates were required since the efficiency of the design relies on the accuracy of the prior parameter estimates (Choice Metrics, 2018).

Rose and Bliemer (2009) discussed the importance of prior parameter values by highlighting the purpose of the stated choice experiment which is to estimate the parameters of the specified model. The authors argue that it is always possible to obtain some information on the priors, even the sign of the parameters is available just by using reasoning alone (Rose and Bliemer, 2009, Johnston et al., 2017). In this study, close to zero priors with the expected parameter signs were used for the pre-pilot survey. To estimate the priors, expert consultation and a review of the literature were required. The priors were then used to build the initial efficient design using the software package Ngene (Rose et al., 2008, ChoiceMetrics, 2018). The initial design was then pre-tested and piloted to validate the design in principle. Data from the pre-pilot were analysed and the resulting parameter estimates were used as priors in a Bayesian D-efficient experimental design to inform an improved (more efficient) DCE design for the final questionnaire (Greiner et al., 2014). The use of Bayesian design methods may be applied to formally reflect uncertainty in expected parameter values (Johnston et al. 2017) since the Bayesian strategy takes account of the uncertainty in the magnitude of the prior parameter estimates. Thus, Bayesian priors are required in order to generate efficient and robust experimental designs for stated choice surveys commonly obtained through a pilot study (Bliemer and Collins, 2016, Sandor and Wedel, 2001).

The next step involves specifying the number of choice tasks. The number of attributes and levels define the number of total possible combinations, which is usually extremely large and therefore it is necessary to select a reasonable number of meaningful choice tasks (Weber, 2019). The use of an efficient experimental design allows the researcher to minimise the number of choice tasks per participant since such designs maximise the precision of estimated parameters of interest for a given number of choice tasks (Weber, 2019).

To measure the efficiency of an experimental design, different criteria are applied (Bliemer and Rose, 2005). Commonly used is the D-optimality criterion that seeks to simultaneously minimise all the elements of the asymptotic covariance matrix of models to be estimated from data collected from an experimental design. Therefore, a design with the lowest D-error is an efficient design (Rose and Bliemer, 2009). After generating several experimental designs, the chosen experimental design with the lowest D-error was used for this study.

The final experimental design included 24 choice tasks blocked into three sets of eight choice tasks each. To reduce the cognitive burden and to avoid tiresomeness, each participant was given eight choice tasks which appeared in a random order (Mohamad et al., 2018). Once the experimental design was created, data collection was organised through a survey (Weber, 2019).

5.1.6 Devising and implementing the survey

To translate the experimental design into a survey for participants, an online questionnaire was set up using the online survey tool Qualtrics. To ensure the DCE was comprehensive and credible to participants, the development of the questionnaire was constructed according to the state-of-the-art recommendations for stated choice studies, including qualitative pretesting (e.g., Choice Metrics, 2018; Johnston et al. 2017). The survey consisted of sections where participants were asked about their travel behaviour, preferred monthly travel plan using a stated choice experiment and their personal sociodemographic situation. The complete version of the final survey can be found in Appendix B.

Survey Contents

The survey contained nontechnical information for clarification purposes. At the start of the survey participants were presented with a consent form describing the purpose of the survey and what it entailed. Once the participant consented to take the survey, they were led to answer screening questions. Participants were screened for their age, residential location, possession of a full driving licence and their mode choice to commute, in order to verify they were eligible for the study. Participants needed to be in possession of a driving licence, between 18 and 64 years old and residing in the West Midlands. The choice of travel mode to commute was asked to filter out participants who walked or cycled to their place of work or study. Such participants were less likely to relate to the hypothetical scenario, and therefore participants who did not satisfy the requirements were filtered out.

The survey took place during the COVID-19 pandemic. Participants were reminded that the questions pertained to their travel behaviour that took place before travel restrictions and government lockdown measures were implemented in March 2020, unless instructed otherwise. Hence, questions on how participants were travelling during such restriction measures were asked to give participants the opportunity to communicate their travel behaviour at the time of taking the survey, before proceeding to questions related to travel prior to March 2020.

The travel behaviour section asked participants on their choice of transport mode and the number of trips taken during a typical week, for commuting and shopping, leisure, and recreational activities. Other questions included access to public transport stops from their home and work or educational institution, their possession of mobility tools including vehicle ownership and the use of a smartphone for travel purposes. After completing their travel behaviour questions, the participants were given instructions and detailed information about the stated choice experiment. To better orient participants to the choice tasks, participants were presented with information and instructions including an example of how the choice task looked like (Figure 15).

We are now going to ask you to choose a monthly travel plan from four available monthly plans.

When making your choice we ask you to imagine that you need to travel to your place of work or study in Birmingham City centre for 3 to 5 days a week.

Your travel distance is 7 miles from your home to your place of work or study.

Links to transport maps are available to show which zones are covered by bus, train and tram services. Please click on the titles in the top row of each column to open the links.

Each choice will be described using a **choice card**, an **example** of which is shown below.

Assume you live 7 miles away from Birmingham City centre.

You need to commute to your place of work or study into Birmingham City centre 3 to 5 days a week.

Please choose the monthly travel plan you would prefer, keeping in mind any money spent on travel cannot be spent elsewhere.

Alternatives / Attributes	**Car -** Use of a private car	**Bus -** Anytime and unlimited use across the West Midlands	**Train -** Anytime and unlimited use within the specified Rail Zones 1 to 5	**MaaS -** Anytime and unlimited use of bus, tram, train within zones 1 to 5, and discounted taxi and car hire
Monthly Cost **Car** - cost of running a car (not including the cost of the car itself) **Bus, Train, or MaaS**: Cost of monthly subscription	£145	£51	£82	£90
In Vehicle Time (minutes) per commute trip Average time taken inside a means of transport	30	30	25	25
Walking Time (minutes) per commute trip Average time taken to walk to a public transport stop or to the car	3	4	12	12
Waiting Time (minutes) per commute trip Average time taken from the instant you arrive at a stop or station and wait until the next scheduled departure	0	12	3	0

Figure 15: Information and instructions were provided for each participant showing what to expect and how to navigate the choice task for information

Following the first instruction and information sheet, a detailed description and explanation for each of the alternatives and attributes was provided. Considering the concept of MaaS was relatively new, a description of the service and how it works was given using an infographic explaining what MaaS was and how it could be used. An example of how MaaS looks like on a smartphone was demonstrated using a mobile screenshot from the mobile application Whim. On a separate page, a set of four true or false questions followed the MaaS explanation to test participants understanding of MaaS before proceeding to the choice tasks.

Each participant was assigned one of the three blocks containing the eight choice tasks at random. The eight choice tasks within each block were shown randomly to participants. The randomisation of choice tasks is considered a good practice to minimise possible bias (Weber, 2019). In the experiment, participants were asked to assume they had to commute 7 miles to their place of work located in Birmingham City Centre, 3 to 5 days per week. Based on the hypothetical situation and the attribute levels, participants had to choose their preferred monthly travel plan out of the four alternatives.

The continuity axiom of consumer behaviour assumes that participants had fully considered each and every attribute presented in a block of choice tasks when deciding which alternative, they preferred most. However, it is generally accepted that there is a limitation on the human capacity to process information (Mohamad et al., 2018). Hence, Greiner et al. (2014) found participants when completing choice experimental tasks often did not consider all attributes presented in the tasks but made a choice on only a sub-set of attributes. Consequently, a combination of the complex choice tasks and a limited respondent cognitive ability may lead to a risk that participants use simplifying strategies or a simplifying heuristic to make a judgement. Mohamad et al. (2018) found there is evidence that individuals who claimed to have ignored some attributes may simply have assigned them lesser or lower importance (e.g., Hess and Hensher, 2010, Hess, 2014) since the most ignored attribute receives the lowest preference ranking in the estimated utility model. There is also evidence that individuals who claimed to have ignored an attribute really did (Carlsson et al., 2010). In other words, there is an inconsistency between what individuals declare and what they really do. Mohamad et al. (2018) suggest including attribute non-attendance (ANA) follow up questions at the end of the choice task. ANA questions are not recommended after every choice task because the questions could affect participants' behaviour in subsequent choice questions and therefore their choice may not reveal their true preferences (Mohamad et al., 2018). Therefore, participants were presented with four follow-up options for each attribute after the last choice task in the block was completed. The approach taken was similar to Hensher and Rose (2009), Carlsson et al. (2010) and Alemu et al. (2013), where participants were asked how often they considered each of the attributes, with a choice between always, sometimes, or never considered.

The survey ended with general sociodemographic questions about the participants' gender, educational status, employment status and household structure.

Online survey implementation

During the data collection process, it transpired that pilot survey participants were comfortable completing the survey on a smartphone or hand-held device. Participants were increasingly responding to web surveys on their smartphones as opposed to their personal computers and this change might have led to some potential data quality issues. However, Antoun et al. (2017) in a randomised crossover experiment to compare the effect of smartphones and personal computers, on response quality in a Web survey, found participants were at least as likely to provide conscientious and thoughtful answers and to disclose sensitive information on both smartphone and personal computers. Overall, the Antoun et al. (2017) found people using smartphones can provide high quality responses, even when their context is more distracting, if they are presented with question formats that are easy to use on small touchscreens. Thus, this survey was optimised to be used on a smartphone. In addition, prior to starting the survey and prior to starting the stated choice experiment, participants were reminded to turn on their auto-rotation function on their smartphone to better view the choice tasks.

The pre-test and pilot study

The purpose of conducting a pre-test or pilot on a few participants was to check that the technical setup of the survey had no issues and that choice tasks were correctly understood by the participants. As stated by Hensher et al. (2005) even though the primary objective of the pilot study was to test the contents and logistics of the survey process, the answers collected from the pilot provide an opportunity to conduct a first econometric analysis and test coefficients are close to their expected value (Weber, 2019).

According to Weber (2019) a reasonable sample size for a pilot survey is around 20 to 40 participants and should be conducted with a sample drawn from the target population for the main study (Johnston et al., 2017). The pre-pilot recruited participants from the study in Chapter 4 who had given their consent to being contacted for further studies. The recruitment for additional participants was made by advertising the study on social media platforms using community groups in the West Midlands. As an incentive five Amazon vouchers of £20 each were included in a prize draw for those who completed the survey. Following the pre-pilot a few changes to the survey were made to make it more comprehensible and visually pleasing to the participants. Changes were made to the wording of the introduction and multiple-option questions as a result of pilot responses.

For the main study, a panel of participants managed by Qualtrics was used. Qualtrics is a market research company with its own cloud-based software that allows the collection of information and generation of data with no hardware required. Using a market research company helped in gaining access to the target population required for this study. The pilot survey was conducted in July and the final survey in August through September 2020.

5.1.7 Statistical analysis

After the data was collected, statistical analysis on the data inferred participants' preferences. The theoretical basis for the specification of the econometric model is the random utility theory (De Dios Ortúzar and Willumsen, 2011, Lancsar and Louviere 2008, McFadden 2001) which provides the economic foundation to analyse the individual's choices (Lancsar and Louviere, 2008). The random utility theory assumes individuals both know their preferences and seek to maximise the utility they derive from each choice task. Taking a choice of *J* alternatives, individuals choose the alternative that is greater than (or equal to) the highest utility *U* (McFadden, 1974, De Dios Ortúzar and Willumsen, 2011). This means individual *i* will evaluate each of the alternatives *J* and choose the one with maximum utility *j* (Equation 1).

$$U_{ij} \geq U_{iJ} \qquad \forall j \neq J$$ *Equation 1*

The utility (U) that an individual receives from the chosen alternative *i* depends on the observed characteristics (attributes) denoted by a systematic component and unobserved characteristics denoted by a stochastic component (Equation 2).

$$U_i = V_i + \varepsilon_i$$ *Equation 2*

The generic random utility equation shown in Equation 2 is specified in this study using the random utility maximisation approach to model the selection of travel mode as shown in Equation 3:

$$U_{ij} = ASC_j + \beta X_i + \gamma Y_j + \epsilon_{ij} \qquad \textit{Equation 3}$$

Where:

ASC_j = alternative specific constants for alternative *j*

U_{ij} utility of individual *i* for alternative *j*

X_i vector of alternative j-related attributes

Y_j vector of socio-economic and travel behaviour characteristics for individual i

β, γ model parameters to be estimated

ϵ_{ij} error term of the model

A model using travel mode attributes was created using a conditional logit to explain mode choice in relation to the alternative specific constants and the travel mode attributes. Each alternative was characterised by only four attributes, monthly cost, in-vehicle time, walking time and waiting time. Hence, each alternative in the choice task had its own linear utility function (Equation 4, Equation 5, Equation 6, Equation 7) depending on the attributes of the alternative. Individuals made their choice by selecting the transport mode that yielded the highest utility.

$$V_{Car} = \beta_{Car} + \beta_{Cost} \times Cost_{Car} + \beta_{TT} \times TT_{Car} + \beta_{WLKT} \times WLKT_{Car} \qquad \textit{Equation 4}$$

$$V_{Bus} = \beta_{Bus} + \beta_{Cost} \times Cost_{Bus} + \beta_{TT} \times TT_{Bus} + \beta_{WLKT} \times WLKT_{Bus} + \beta_{WT} \times WT_{Bus} \qquad \textit{Equation 5}$$

$$V_{Train} = \beta_{Train} + \beta_{Cost} \times Cost_{Train} + \beta_{TT} \times TT_{Train} + \beta_{WLKT} \times WLKT_{Train,s} + \beta_{WT} \times WT_{Train} \qquad \textit{Equation 6}$$

$$V_{MaaS} = \beta_{Cost} \times Cost_{MaaS} + \beta_{TT} \times TT_{MaaS} + \beta_{WLKT} \times WLKT_{MaaS} + \beta_{WT} \times WT_{MaaS} \quad \text{Equation 7}$$

Where:

V_i is the systematic utility for alternative *i*,

$Cost_i$ is the level of the monthly cost for alternative *i*,

TT_i is the level of the in-vehicle travel time for alternative *i*,

$WLKT_i$ is the level of the walking time for alternative *i*,

WT_i is the level of the waiting time for alternative *i* and;

β_{Car} ,β_{Bus} ,β_{Train} ,β_{Cost} ,β_{TT} ,β_{WLKT} and β_{WT} are unknown (preference) parameters that are to be estimated[2].

We assume that all alternatives have identically and independently extreme value type I distributed random unobserved components. The probability of an individual choosing alternative *i* out of a set of *J* alternatives is equal to the ratio of the exponential observed utility index for alternative *i* to the sum of the exponentials of the observed utility indices for all *J* alternatives, including the *i*th alternative. This is given by the following conditional logit model (Equation 8):

$$Prob_i = \frac{\exp V_i}{\sum_{j=1}^{J} \exp V_j} \quad \text{Equation 8}$$

To examine the impacts of individual characteristics on the choice of alternative independently of the travel mode attributes, a multinomial logit model was estimated using socio-economic and travel behavioural variables (Equation 9).

$$U_{ij} = ASC_j + \gamma Y_j + \epsilon_{ij} \quad \text{Equation 9}$$

[2] The results of the β_{Car} , β_{Bus} , β_{Train} , β_{Cost}, β_{TT} , β_{WLKT} and β_{WT} from the pilot phase study were used to build the experimental design as discussed in section 5.1.5.

Following this, the generic random utility equation as shown in Equation 2 was specified in this study using the random utility maximisation approach to model the selection of travel mode as shown in Equation 8. This type of model is useful for reproducing, describing, or evaluating situations where individuals must select an option from a finite set of alternatives (De Dios Ortúzar and Willumsen, 2011).

In summary, the multinomial logit (MNL), conditional logit (CL) and general random utility model (RUM) explained the expected utilities using different variables. The MNL and CL models are the most widely used tools for analysing discrete dependent variables. The terminology is not consistent in the literature, but the MNL model is referred to as a special case of a CL model in which all explanatory variables are individual specific which means the expected utilities are modelled in terms of characteristics of the individuals. In CL models, the expected utilities are modelled in terms of characteristics of the alternatives rather than the attributes of the individual. When combining the MNL and CL formulations a general model is obtained where the underlying utilities depend on characteristics of the individuals as well as attributes of the choices. Therefore, this allows for two types of independent variables: alternative specific and case specific. Alternative specific variables vary among the alternatives and the cases, and case-specific variables vary only among cases.

STATA version 16 (StataCorp, 2019) was used to estimate the models.

Model Fit and Validation

A market share model was prepared using a multinomial logit (Equation 10), which was then used to fit and validate the forthcoming models. The market share model acts as a null model (De Dios Ortúzar and Willumsen, 2011) estimated with constants only assuming equal market shares (Hensher et al., 2005) and used to compare with other estimated models to verify which model is the superior model. Thus, if the fitted model does not statistically improve the Log-likelihood function, then the additional attributes and variables do not improve the overall model fit beyond the base model and therefore the best estimate available is the assumed market share (Hensher et al., 2005).

$$V_{ij} = ASC_{car} + ASC_{bus} + ASC_{train} + ASC_{MaaS} \qquad \textit{Equation 10}$$

To measure how well the model, with its estimated parameters, performs compared with a model in which all parameters are zero (market share model, equation 10) the likelihood ration index is used (Train, 2009). This is expressed as rho-square value, however, because the choice analysis of the multinomial logit model is non-linear, it differs from the R^2 statistics associated with linear regression models. Hence, a model fit between the range 0.3 and 0.4 for a discrete choice model can already be considered a good fit as it equals R^2 between 0.6 and 0.8 for the linear model equivalent (Hensher et al., 2005).

The likelihood ratio index compares the intercept only model to the likelihood ratio index for the model with the predictors (Equation 11).

$$R^2McF = 1 - \frac{InL(M_{full})}{InL(M_{null})}$$

Equation 11

The adjusted version of McFadden's R^2 subtracts K, the number of parameters in the model (Equation 12). Thus, the adjusted McFadden's R^2 is to McFadden's R^2 as the adjusted R^2 is to R^2 in ordinary least squares regression.

$$R^2McF = 1 - \frac{InL\left(M_{full}\right) - K}{InL(M_{null})}$$

Equation 12

An alternative goodness of fit statistic is the percent correctly predicted which Train (2009) recommends avoiding. This statistic is calculated by identifying for each sampled decision maker the alternative with the highest probability, based on the estimated model and determining whether – or not – this is the alternative that the decision maker actually chose. The percentage of sampled decision makers for which the highest probability alternative and the chosen alternative are the same is called the percent correctly predicted.

5.2 Results and analysis

A total of 568 workers and 209 students completed responses were collected. Both groups were analysed separately and compared in the discussion. This chapter starts with the sociodemographic characteristics and travel behaviour patterns of the participants and continues with the results of the choice experiment.

5.2.1 Sociodemographic characteristics and mobility tools

Efforts were made to match the distribution of the survey sample characteristics to the population of workers in the West Midlands, however having a niche target population made it more challenging. Using the available datasets from the Office for National Statistics (ONS), the recent data on commuting to work by gender, UK country and region was available from the Labour Force Survey (October to December 2017) covering all in employment (16+). To verify the latest statistics on the population residing and commuting to work in the West Midlands, contact was made with the Social Survey Department after consulting the Labour Market and Households Division from where the data on commuting to work by gender, UK country and region was released (ONS, 2018). In communication, the total population commuting to work in the West Midlands weighted using the 2017 population, was of 2,133,676 people in employment (16+). Only 1,945,186 people were found to commute by motorised transport excluding walking and other methods. Advice was given to be cautious when breaking down the sample by gender, as sample sizes were quite small for this variable and level of detail for specific transport modes was lacking. Thus, using the total number of commuters excluding gender, Table 27 shows comparisons of the usual method of commuting found in the Labour Force Survey compared to the survey for this study. This survey underrepresents workers commuting by car, van, or minibus while workers using other methods of travel are overrepresented. Therefore, caution should be exercised when interpreting the results with the current sample, or it should be weighted if the results are to be generalised.

Table 27: Data on mode of commute to work in the UK, released in November 2018 by the Office of National Statistics for the West Midlands, compared to the data on mode of commute from this study

Usual method of travel to work (Labour force Survey Oct-Dec 2017)	Number of participants	%	Transport modes used within a week by participants to travel to their workplace	Number of participants	%
Car, van, minibus	1,680,763	86.41	Private Car driver Private Car passenger, Carshare or Rideshare	381 72 11	81.7
Motorbike, moped, scooter	10,119	0.52	Electric bike Motorcycle	6 3	1.6
Bicycle	48,910	2.51	Private bicycle public share bicycle	19 17	6.3

Usual method of travel to work (Labour force Survey Oct-Dec 2017)	Number of participants	%	Transport modes used within a week by participants to travel to their workplace	Number of participants	%
Bus, coach, private bus	119,466	6.14	Bus coach work shuttle bus	136 4 2	25.0
Taxi	9,348	0.48	Taxi Uber	24 26	8.8
Railway train	71,821	3.69	Train	74	13.0
Underground train, light railway, tram	4,759	0.24	Tram	18	3.2
Total (excluding statistics on walking and other methods)	**1,945,186**				

Focusing on the sample of participants used in this study, the travel behaviour and socio-economic characteristics for the survey sample are presented in Table 28. The workers' sample was mainly composed of females (64.4%) and full-time employees (73%). The age distribution was normal (skewness 0.524, kurtosis 0.481) and half of the workers sample hold an educational qualification from a higher educational institution. For workers, the annual household income before tax was distributed evenly across the range provided. However, most of the participants fell on the higher end of the scale. Meanwhile, the annual household income before tax for students was distributed across all ranges with the majority falling at the lower end of the scale.

With reference to the student sample most of the sample was also found to be female (58.9%). Statistics from HESA (2021a) show the number of female students attending full-time education was 56% compared to 43.9% males in educational institutions located in the West Midlands during the 2019/2020 academic year. The remaining 0.1% identified as other. Hence, the sample over represents student females while it underrepresents student males. With reference to the age distribution, HESA (2021b) provided data on the age distribution of students attending a higher education institution in the West Midlands. Since data on the age for full-time students only is not available, the age distribution for both full-time and part-time students was used. The 18-29 age group for both full-time and part time students during the academic year 2019/2020 was of 80.9% with 19% of students falling under the 30 and over category. The remaining 0.1% were unknown. Hence, the sample underrepresents the 18-29 age group while it over represents the students in the 30 and over category. Thus, caution should be exercised when interpreting results.

In terms of the household composition, more than half of the worker sample (53.2%) lived with children of which 45.8% were aged 15 or younger. In comparison, more than half of the student sample did not live in a household with children. In terms of housing tenure, more than half of the workers sample said they owned a house whereas more than half of the student sample either lived in a parental or guardian home or rented a property. With reference to the number of cars in the household, more than half of the student and worker samples lived in households with at least one car available.

Other features which characterise the sample in this study were the possession of mobility tools. Car ownership was higher for workers (82.9%) compared to students (53.6%). In terms of participants' experience with using a smartphone for travel purposes, both students (91.9%) and workers (86.1%) said they used their smartphone to mainly plan their travel routes, use maps and navigation systems, and check live travel times.

Table 28: Sociodemographic characteristics and mobility tools available for the worker and student samples

Variable	**Total workers sample n=568 (%)**		**Total student sample n=209 (%)**
Gender			
Male	35.6		41.1
Female	64.4		58.9
Age	Mean = 34.42 S.D = 8.57		Mean = 24.50 S.D. 6.75
18-29	28.5		79.4
30-39	44.4		15.8
40-49	23.2		4.3
50-59	2.5		0.5
60-64	1.4		0.0
Household Income			
less than £15,000	8.3		14.8
£15,000 - £19,999	10.4		13.4
£20,000 - £24,999	11.1		12.4
£25,000 - £29,999	11.6		12.4
£30,000 - £34,999	8.6		6.2
£35,000 - £39,999	6.7		4.3

Variable	Total workers sample n=568 (%)		Total student sample n=209 (%)
£40,000 - £44,999	9.2		8.1
£45,000 - £54,999	12.3		4.8
£55,000 or more	16.9		9.6
No information (don't know or prefer not to say)	5.0		13.9
Education Level		**Level of Study**	
No formal qualification	1.9	HND/Foundation	6.2
GCSE or equivalent	18.0	Undergraduate	58.9
A level	16.4	PGCE	4.8
Vocational qualifications (such as apprenticeships)	13.4	Postgraduate	20.1
Undergraduate Degree	33.3	PhD	5.3
Postgraduate Degree	14.4	Other	4.8
PhD	1.6		
Other School qualifications	1.1		
House tenure			
Parental or guardian home	11.8		41.1
Owned home	51.8		29.2
Rented property	36.1		23.0
Other	0.4		6.7
Household composition			
HH with no children	46.8		66.0
HH with children	53.2		34.0
HH with children of which consist of:			
15 years or younger	45.8		29.7
Older than 15 years	11.8		9.6
Both 15years younger and older	4.4		5.3
Number of vehicles available in the household			
None	6.3		9.1
1	50.4		54.5
2	37.9		24.9
3	4.9		7.7
4 or more	0.5		3.8
Car Ownership Status			

Variable	Total workers sample n=568 (%)		Total student sample n=209 (%)
Own	82.9		53.6
Access to someone else	10.7		31.6
Neither own nor have access to someone else’s	6.3		14.8
Use their smartphone for travel purposes			
Yes	86.1		91.9
No	13.2		7.7
Do not own a smartphone	0.7		0.5
Use of Smartphone for Travel purposes calculated from the total number of participants.			
Route planning or route planning apps	67.1		64.6
Maps, navigation, or satnavs	65.0		57.4
Checking live travel times (e.g., bus, train, tram, fights etc.)	43.3		46.4
Buying train, bus, or other public transport tickets online	32.7		33.0
Checking traffic updates	34.5		16.7
Booking a taxi or minicab using Uber	29.8		34.4
Booking a taxi or minicab using another app (not Uber)	16.2		17.7
Paying for taxi services online	11.3		16.3
Finding out about services available in the area (e.g., restaurants, cafes, shops, garages)	36.6		25.4

5.2.2 Revealed travel behaviour: access to nearby transit modes

The mode of travel frequently used by participants to commute to work, or university was identified in order to be compared with the participants’ preferences in the DCE survey. Mode use frequency was analysed using the method found in Ho et al. (2020). The number of trips during a given week defined mode use frequency. For public transport modes, 1-4 trips per week were considered infrequent, 5-8 trips per week were considered frequent and 9+ trips per week were considered as very frequent. The data for the workers sample in Figure 16 shows the highest percentage of very frequent users (26.2%) used their car, followed by the bus (5.3%), car passenger (3%) and train (2.8%). Similarly, frequent users were found to be car drivers (26.9%) followed by the bus (7%), car passenger (3.9%) and the train (2.3%).

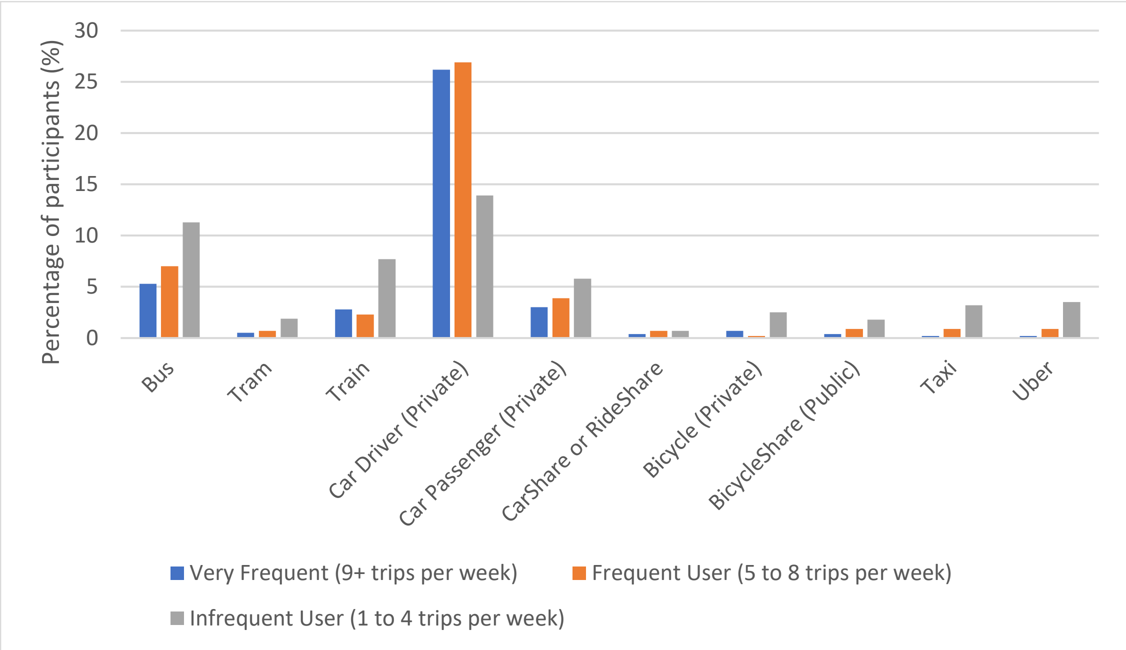


Figure 16: Mode use frequency for workers commuting to their workplace

Looking at the number of trips by each mode, the data for student participants shown in Figure 17 indicates that there was a higher share for weekly trips by bus, with the highest percentage of very frequent users (7.7%). Frequent users were also found for the bus (16.7%) followed by the train (9.6%) and the car as driver (7.2%). Most of the transport modes were used infrequently (1 to 4 trips per week) which was expected considering students may not need to travel to their university campus every day of the working week unlike workers.

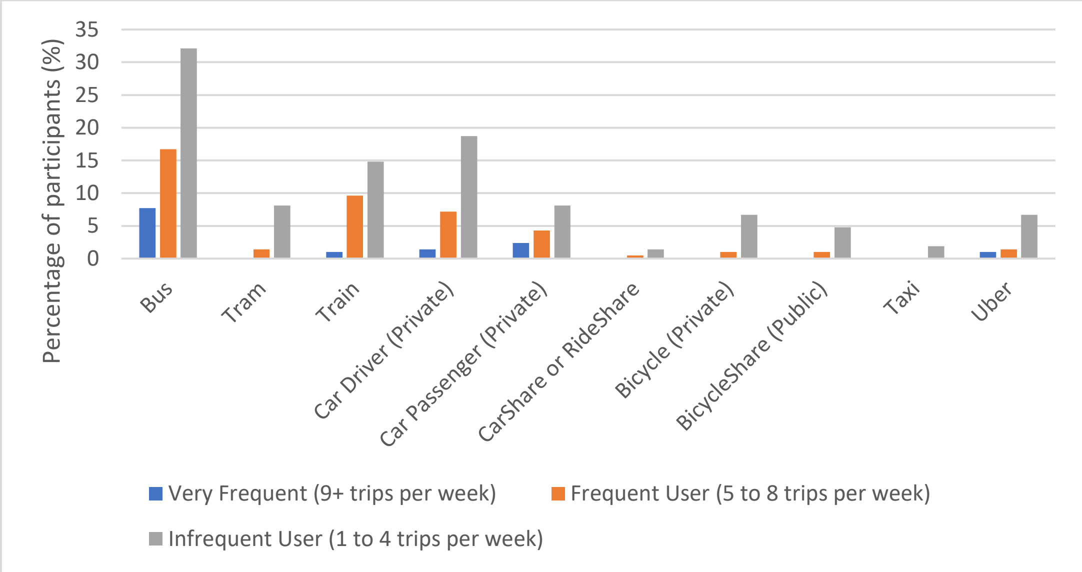


Figure 17: Mode use frequency for students commuting to university

To summarise, Table 29 shows how on average workers made more weekly trips by private car, followed by the bus and the train, whereas students made more weekly trips using the bus, followed by the train and the private car. These results show how both workers and students have different travel mode preferences which will then be compared to their stated choices in the DCE.

Table 29: Reported number of weekly trips done by workers commuting to work and students commuting to university

Sample	Number of trips per week for the	Mean (SD)
Workers (n=381)	private car (driver)	7.64 (5.28)
Students(n=57)		3.86 (2.87)
Workers (n=134)	bus	5.39 (5.00)
Students(n=118)		4.47 (3.04)
Workers (n=73)	train	4.73 (3.21)
Students(n=53)		4.32 (2.91)

5.2.3 Discrete choice analysis

A total of 777 participants completed the stated choice experiment providing a total of 6,216 choice tasks. Table 30 shows the number of times the alternatives were selected by both workers and students. It is useful to examine the distributions of the participants' mode choice preference in the choice experiments compared to their frequent use of transport modes. Results show both workers and students stuck to their status quo (Workers = car, Students =

bus) with MaaS being preferred more by workers than students. However, this comparison should be done with caution as the choices were dependent on the attribute levels. Therefore, results in Table 30 can only be used to observe general trends in the choice data.

Table 30: Comparing reported mode of travel with preferred choice from the stated choice experiment

	Workers (n=568) **Choice tasks (%)**	**Students (n=209)** **Choice tasks (%)**
Current Mode: Car	381 (67.1%)	58 (27.8%)
Stated Preference Mode choice: Car	**1,353 (29.8%)**	**317 (18.9%)**
Current Mode: Bus	136 (23.9%)	122 (58.4%)
Stated Preference Mode choice: Bus	**1,093 (24.0%)**	**588 (35.2%)**
Current Mode: Train	74 (13.0%)	54 (25.8%)
Stated Preference Mode choice: Train	**971 (21.4%)**	**416 (24.9%)**
Stated Preference Mode choice: MaaS	**1,127 (24.8%)**	**351 (21.0%)**

To explain mode choice in relation to the alternative specific constants (ASCs) and travel mode attributes, a conditional logit model was used (Table 31). The travel mode attributes are the cost, in-vehicle time, waiting time and walking time. The ASCs represent preferences that are inherent and independent of specific attribute values. Thus, for the workers sample the ASCs were significant at the 99.9% confidence level showing the preference for the private car was stronger compared to the other modes of travel. In the case of the student sample the non-significance of the ASCs implies that there was no difference in preference when students were faced with a choice between travel modes, assuming that their attributes were identical. In terms of the travel mode attributes for both samples these were negative and significant at the 99.9% confidence level, except for waiting time for the student sample which was significant at the 90% confidence level. These results show both workers and students were mindful of the cost and time, causing a reduction in utility for all alternatives and the chosen probability of an alternative.

Table 31: Results of the travel mode attributes model using a conditional logit model

Variables	Parameters	Worker sample Travel mode attributes model		Student sample Travel mode attributes model	
		Parameter estimate (std error)	Robust t-test	Parameter estimate (std error)	Robust t-test
Alternative Specific Constants	Car	reference		reference	
	Bus	-0.86 (0.24) ***	-3.56	0.14 (0.40)	0.36
	Train	-1.12 (0.22) ***	-5.00	-0.27 (0.37)	-0.74
	MaaS	-0.60 (0.16) ***	-3.40	-0.17 (0.29)	-0.60
Travel mode attributes	Cost	-0.02 (0.001) ***	-11.25	-0.01 (0.002) ***	-4.76
	In-vehicle time	-0.07 (0.01) ***	-9.21	-0.04 (0.06) ***	-4.05
	Walking time	-0.09 (0.01) ***	-6.80	-0.07 (0.04) ***	-3.29
	Waiting time	-0.02 (0.01) ***	-3.67	-0.02 (0.01)	-1.94
Sample size	Worker = 568 Student = 209				
McFadden's Pseudo R^2	Worker = 0.03 Student = 0.03				

Note: **pvalue* <0.05 ***pvalue* <0.01 ****pvalue* <0.001

To examine the impacts of individual characteristics on the choice of alternatives independently of the travel mode attributes, a multinomial logit model was used using the socio-economic and travel behaviour variables. Based on the literature review, different variables were chosen for each sample to examine the impact on mode choice. This meant, for the workers sample the car ownership dummy was excluded from the model; a large proportion of workers owned a car. Otherwise, the two variables would be highly correlated, and the log-likelihood function would fail to produce valid estimates (Son and Chinh, 2017). With reference to the student sample, age was not included in the model due to the homogeneity across the dataset (Danaf et al., 2014); most of the student participants were below 25 years old. The results for the worker and student sample are presented separately below.

Worker sample

As shown in Table 32 the multinomial logit model used the private car as a reference since this was the most chosen alternative by the workers' sample. Results show the coefficient for males across all transport modes was negative and significant at the 99.9% confidence level implying males have a higher preference for the car. The positive coefficient sign for age was significant at the 99.9% for bus and train and 95% confidence level for MaaS. The positive coefficient sign suggests with an increase in age participants were likely to choose the bus, train or MaaS over the private car. With reference to employment status, full-time employees were more likely to choose the private car since all other transport options had a negative and significant coefficient sign at least at the 95% confidence level.

As expected, an increase in the number of cars in the household increased the likelihood for participants to choose the private car. The coefficient for participants who had children living in their household was negative for all transport options with the highest parameter value significant at the 99.9% confidence level for the train. This suggests workers who had children in the household were more likely to choose the private car. The coefficient for experience in booking and paying for public transport services using a smartphone was found positive for all transport options with the highest parameter value for MaaS, having a significant coefficient at the 99.9% confidence level. This implies workers with experience in booking and paying for public transport services using a smartphone were more likely to choose MaaS over the private car. The influence of having a university degree on mode choice was found to be positive for all transport options but only significant at the 99% confidence level for MaaS, suggesting participants with a university degree were more likely to choose MaaS over the private car.

As expected, high income households show a negative coefficient for the bus and train with a significance at the 99% and 95% confidence level, respectively. This suggests participants in higher income households were more likely to choose the private car. On the contrary, the coefficient for higher income households was found to be positive for MaaS although not significant.

To examine the influence of participants' usual commute with choice, the results show the coefficient for usual type of commuting relative to the choice of transport option was as expected. Bus commuters and train commuters were found to have positive and significant coefficients at the 99.9% confidence level suggesting participants who usually commuted by bus and train were likely to choose the same transport mode. Nevertheless, train commuters were found more likely to choose the bus over the private car given by the significant coefficient at the 99.9% confidence level. As expected, car driver commuters were less likely to choose MaaS or any of the other transport modes over the private car given the negative and significant coefficients at the 99.9% confidence level. The coefficient for usual type of commuting relative to MaaS was interesting to note. The coefficient for bus and train commuter was positive, however, the coefficient was significant at the 99.9% confidence level only for the train commuter. Suggesting train commuters were more likely to choose MaaS.

Table 32: Multinomial logit model estimating the impact of individual characteristics on mode choice independent of the travel mode attributes for the worker sample

Variables	Bus		Train		MaaS	
	Parameter estimate (std error)	**Robust t-test**	**Parameter estimate (std error)**	**Robust t-test**	**Parameter estimate (std error)**	**Robust t-test**
Male	-0.35 (0.09) ***	-3.72	-0.61 (0.11) ***	-6.10	-0.41 (0.09) ***	-4.38
Age (continuous)	0.02 (0.004) ***	4.71	0.01 (0.004) ***	3.76	0.01 (0.004) *	2.23
Household with children	-0.10 (0.09)	-1.17	-0.39 (0.09) ***	-4.23	-0.20 (0.09) *	-2.25
Employed full-time	-0.33 (0.10) ***	-3.30	-0.34 (0.10) ***	-3.29	-0.23 (0.10) *	-2.30
Experienced with booking and paying via smartphone	0.28 (0.09) **	3.10	0.58 (0.09) ***	6.29	0.73 (0.08) ***	8.38
High income (>=£45K)	-0.34 (0.11) **	-3.16	-0.21 (0.10) *	-2.00	0.06 (0.11)	0.67
Number of cars available in the household (continuous)	-0.34 (0.06) ***	-5.31	-0.17 (0.06) **	-2.64	-0.15 (0.06) *	-2.47
University degree	0.07 (0.09)	0.73	0.06 (0.09)	0.64	0.26 (0.09) **	2.86
Car driver commuter	-4.11 (0.12) ***	-3.40	-0.36 (0.12) **	-2.95	-0.53 (0.11) ***	-4.58
Bus commuter	0.85 (0.12) ***	6.99	-0.50 (0.14) ***	-3.59	0.03 (0.12)	0.26
Train commuter	0.63 (0.17) ***	3.71	1.73 (0.16) ***	10.96	0.81 (0.16) ***	5.01
Sample size	540					
McFadden's Pseudo R^2	0.11					

*Note: *pvalue* <0.05 ***pvalue* <0.01 ****pvalue* <0.001

When estimating the random utility model (Table 33) workers were found to prefer transport options that were cheaper and faster given by the negative coefficients for cost and the three travel time attributes. Male participants were more likely to prefer the car however those who had a university degree were more likely to choose MaaS over the private car. Living in a high-income household increased the preference for MaaS over the bus and train due to the negative and significant coefficient at the 99.9% confidence level for both alternatives.

Experience in booking and paying for public transport or taxi services using a smartphone decreased the preference of all alternatives with the magnitude being higher for the private car followed by the bus and train. This suggests workers with experience in booking and paying for transit or taxi services using a smartphone were most likely to choose MaaS over the private car, bus, and the train. With regards to the participants preferences in relation to their age, the latter was removed from the random utility model due to the coefficient not being significant at the 90% confidence level (Kelly and Williams, 2007).

When it came to the usual commute mode and the possibility of shifting from usual commute to an alternative travel mode, as expected, workers who commuted by private car, bus or train were more likely to choose their usual type of commute. The possibility of commuters shifting to MaaS were found to be bus and train commuters. Bus commuters favoured MaaS over the train shown by a negative and significant coefficient at the 99.9% confidence level. Train commuters favoured MaaS over the private car and bus shown by a significant coefficient at the 99.9% and at least at the 95% confidence level, respectively, with the highest parameter for the private car.

Overall, the preference for MaaS over the private car was among workers who had a university degree and had experience with booking and paying for public transport services using a smartphone. Hence, this augurs well for young adults graduating from university and entering the workforce to be more inclined to use MaaS instead of purchasing a car. Living in a high-income household was found to increase the preference for MaaS over the bus and train, hence a MaaS subscription was expected to be more costly than the single mode transport subscriptions. Thus, similar to how the literature reports an increase in income leads to the purchase of a car, an increase in income can shift a consumer from purchasing a car to purchasing a MaaS subscription.

Table 33: Estimated random utility model for the worker sample

Variables	Parameters	Random Utility Model	
		Parameter estimate (std error)	Robust t-test
Alternative Specific Constants	Car	0.83 (0.21) ***	3.96
	Bus	0.42 (0.15) **	2.86
	Train	-0.27 (0.09) **	-2.81
	MaaS	reference	
Travel mode attributes	Cost	-0.02 (0.001) ***	-11.16
	In-vehicle time	-0.07 (0.01) ***	-9.07
	Walking time	-0.10 (0.01) ***	-6.79
	Waiting time	-0.03 (0.01) ***	-3.90
Case specific variables	Male x car	0.32 (0.07) ***	4.16
	Male x train	-0.24 (0.09) **	-2.66
	Full-time x bus	-0.17 (0.08) *	-1.99
	Experienced with booking and paying via smartphone x private car	-0.84 (0.09) ***	-9.56
	Experienced with booking and paying via smartphone x bus	-0.58 (0.09) ***	-6.15
	Experienced with booking and paying via smartphone x train	-0.20 (0.09) *	-2.12
	High income (>=£45K) x bus	-0.43 (0.09) ***	-4.43
	High income (>=£45K) x train	-0.34 (0.09) ***	-3.88
	Number of cars available in the household x bus	-0.26 (0.06) ***	-4.46
	University degree x car	-0.19 (0.07) **	-2.70
	Car driver commuter x car	0.32 (0.08) ***	3.73
	Bus commuter x bus	0.83 (0.09) ***	8.78
	Bus commuter x train	-0.56	-5.03

Variables	Parameters	Random Utility Model	
		Parameter estimate (std error)	Robust t-test
		(0.11) ***	
	Train commuter x car	-0.92 (0.16) ***	-5.74
	Train commuter x bus	-0.33 (0.13) *	-2.42
	Train commuter x train	0.79 (0.12) ***	6.73
Sample size	540		
McFadden's Pseudo R^2	0.13		

Note: **pvalue* <0.05 ***pvalue* <0.01 ****pvalue* <0.001

Student sample

As shown in Table 34 the multinomial logit model used the bus as a reference since this was the most chosen alternative by the student sample. Results show the coefficient for households with an income at £24,999 or lower, was negative and highly significant at 99.9% confidence level for all transport options. This meant students living in low-income households were more likely to choose the bus over the private car and MaaS. The influence of car ownership on choice was positive for the car, train and MaaS. The coefficients were significant for all alternatives at the 99.9% confidence level, with the highest parameter value belonging to the private car followed by MaaS and the train. This suggests students who owned a car were more likely to choose any of the alternatives available except for the bus.

Students who reported to live in their parents or guardian home were more likely to prefer the bus over any of the alternatives with the highest parameter value found for MaaS followed by the private car, having negative and significant coefficients at the 99.9% confidence level. Another variable which was included and reported to influence mode choice by Zhou (2012), was a monthly or annual public transport subscription. The negative and significant coefficients suggest that students with a public transport subscription preferred the bus over the private car, train or MaaS. This was explained by the cost of a monthly bus pass which would be cheaper than any of the alternatives in this study.

Table 34: Multinomial logit model estimating the impact of individual characteristics on mode choice independent of the travel mode attributes for the student sample

Variables	Car		Train		MaaS	
	Parameter estimate (std error)	Robust t-test	Parameter estimate (std error)	Robust t-test	Parameter estimate (std error)	Robust t-test
Public transport subscription	-0.74 (0.13) ***	-5.48	-0.41 (0.13) **	-3.14	-0.27 (0.13) *	-2.05
Living in parents or guardian home	-0.71 (0.14) ***	-4.82	-0.17 (0.13)	-1.33	-0.77 (0.14) ***	-5.31
Household income (<=£24,999)	-0.63 (0.13) ***	-4.69	-0.54 (0.13) ***	-4.20	-0.62 (0.13) ***	-4.73
Car/Van ownership	1.04 (0.12) ***	8.33	0.40 (0.12) ***	3.19	0.68 (0.12) ***	5.42
Sample size	180					
McFadden's Pseudo R^2	0.17					

Note: **pvalue* <0.05 ***pvalue* <0.01 ****pvalue* <0.001

When estimating the random utility model (Table 35), the travel mode attributes had the expected negative coefficient sign and were significant at least at the 95% confidence level except for waiting time. Students commuting to their place of study preferred transport options that were cheap and fast. The probability of students choosing MaaS were car owners who were less likely to choose a subscription for the bus and the train, and students with a public transport pass who were more likely to choose MaaS over the private car and the train. Students less likely to choose MaaS were car owners who preferred their car, lived in their parents or guardian home, and came from low-income households. The positive and significant coefficients at the 99.9% confidence level implied they were unlikely to choose MaaS.

Overall, the preference for MaaS was reported for student car owners who although preferred their car they would prefer to buy a MaaS subscription over a bus or train subscription. Students living in a low-income household were more likely to subscribe to a bus subscription over MaaS considering that a MaaS subscription was more costly when compared to the bus and train subscriptions.

Table 35: Estimated random utility model for the student sample

Variables	Parameters	Random utility model	
		Parameter estimate (std error)	Robust t-test
Alternative Specific Constants	Car	0.02 (0.36)	0.06
	Bus	0.49 (0.20) *	2.41
	Train	0.23 (0.19)	1.20
	MaaS	reference	
Travel mode attributes	Cost	-0.01 (0.003) ***	-4.99
	In-vehicle time	-0.04 (0.01) ***	-3.37
	Walking time	-0.06 (0.02) *	-2.47
	Waiting time	-0.01 (0.01)	-1.37
Case specific variables	Public transport pass x car	-0.29 (0.14) *	-2.01
	Public transport pass x train	-0.36 (0.13) **	-2.76
	Living situation: Parents or guardian home x bus	0.39 (0.13) **	2.90
	Living situation: Parents or guardian home x train	0.26 (0.15)	1.75
	Income less than £24,999 x Bus	0.32 (0.12) **	2.69
	Car/Van owner x car	0.75 (0.19) ***	3.87
	Car/Van owner x bus	-1.04 (0.15) ***	-6.63
	Car/Van owner x train	-0.59 (0.16) ***	-3.57
Sample size	180		
McFadden's Pseudo R^2	0.20		

Note: **pvalue* <0.05 ***pvalue* <0.01 ****pvalue* <0.001

Model Fit and Validation

Following the statistical analysis outlined in Section 5.1.7, the generated models were compared to a market share model (Table 36). As explained previously, the market share model is where all parameters are zero (equation 10). The purpose of the market share model is to measure how well the other models (travel modes attributes model, random utility model), perform using the rho-square value. As explained in Section 5.1.7 a model fit between the range 0.3 and 0.4 for a discrete choice model can already be considered a good fit as it equals R^2 between 0.6 and 0.8 for the linear model equivalent (Hensher et al., 2005). In terms of model fit, the random utility model was more well suited to explain the behaviour of worker and student samples than the travel mode attributes model. The Log-likelihood, Akaike Information Criteria (AIC) and Bayesian Information Criteria (BIC) of the random utility model were higher compared to the other models (Table 37). However, the value falls short in being considered a good fit according to Hensher et al., (2005).

Table 36: Market share model estimates

Variables	Parameters	Worker sample Market Share Model		Student sample Market Share Model	
		Parameter estimate (std error)	Robust t-test	Parameter estimate (std error)	Robust t-test
Alternative Specific Constants	Car	reference		reference	
	Bus	-0.21 (0.04) ***	-5.25	0.62 (0.07) ***	8.87
	Train	-0.33 (0.04) ***	-7.89	0.27 (0.07) ***	3.65
	MaaS	-0.18 (0.04) ***	-4.53	0.10 (0.07)	1.31
Sample size	Worker = 568 Student = 209				
McFadden's Pseudo R^2	Worker = 0.005 Student = 0.02				

*Note: ***pvalue <.001*

Table 37: Model fit estimates for both the worker and student samples

	Worker sample			Student sample		
	Market Share	Travel mode attributes model	Random utility model	Market Share	Travel mode attributes model	Random utility model
Log likelihood	-6266.33	-6123.27	-5482.82	-2268.22	-2238.23	-1831.64
McFadden Pseudo R^2	0.005	0.03	0.13	0.02	0.03	0.20
McFadden Adjusted Pseudo R^2			0.13			0.20
AIC	12538.67	12260.55	11011.65	4542.44	4490.47	3693.29
BIC	12562.09	12315.20	11158.18	4562.86	4538.12	3772.37
Df	3	7	23	3	7	15
Number of observations	18,176	18,176	4,320	6,688	6,688	1,440
Sample size	568	568	540	209	209	180

Attribute non-attendance results

After completing the eight stated choice tasks, participants were asked how often they took into consideration the travel mode attributes when choosing their preferred alternative. The responses to the stated attribute non-attendance questions are summarised in

Table 38. As shown, the attribute which was reported as 'never' considered was walking time for both groups (17.3% of working participants and 13.9% of student participants) and the attribute 'always' considered was cost (71.3% of participants for each group).

The results show that some of the participants did indeed ignore certain attributes when making their decision. Moreover, some of the participants put less emphasis on certain attributes when making the trade-off between all attributes presented in the choice tasks. The results presented in

Table 38 clearly reveal that only a very small percentage of participants did not attend to all attributes presented in the choice tasks. Lancsar and Louviere (2006) argued that deleting ‘irrational’ responses was not appropriate and removal of such participants might cause the removal of valid responses. Thus, such participants were included in the dataset.

Table 38: The most and least ignored attributes by participants

		In the choices that you have just made on your travel preferences for a given month on travelling to your place of work or study, how often did you consider each of the following individual trip characteristics when making your choice?			
		Monthly Cost (£)	**In-vehicle time (minutes)**	**Walking time (minutes)**	**Waiting time (minutes)**
Always considered	**Worker**	71.3%	39.3%	35.7%	36.1%
	Student	71.3%	38.8%	39.7%	37.3%
Sometimes Considered	**Worker**	20.8%	50.7%	47.0%	48.8%
	Student	25.4%	49.8%	46.4%	49.8%
Never Considered	**Worker**	7.9%	10.0%	17.3%	15.1%
	Student	(3.3%	11.5%	13.9%	12.9%
Total Number of Participants never considered any of the attributes					
Worker	3.2%				
Student	1.4%				

Likelihood of reducing car use and giving up car ownership

The stated choice experiment placed participants in a forced choice setting, meaning that they did not have the option to choose none or opt out. After the experiment, participants who used their car to travel to work or university, were asked if they were willing to reduce their car use. If they replied with likely, they were then asked if they would go a step further and give up their car.

Figure 18 and Figure 19 give an overview of the participants' likelihood to reduce their car use and give up their car. The student sample was found to be more likely to reduce their car use compared to the workers' sample. In terms of whether they would be willing to give up car ownership, workers were found to be reluctant in giving up car ownership in comparison to students. This could be the result of different travel needs to accommodate different lifestyles and personal commitments as well as the investment of owning a car. This is in line with studies that report younger generations to have a different view on car ownership with less young adults opting to choose the car (Chatterjee et al., 2018).

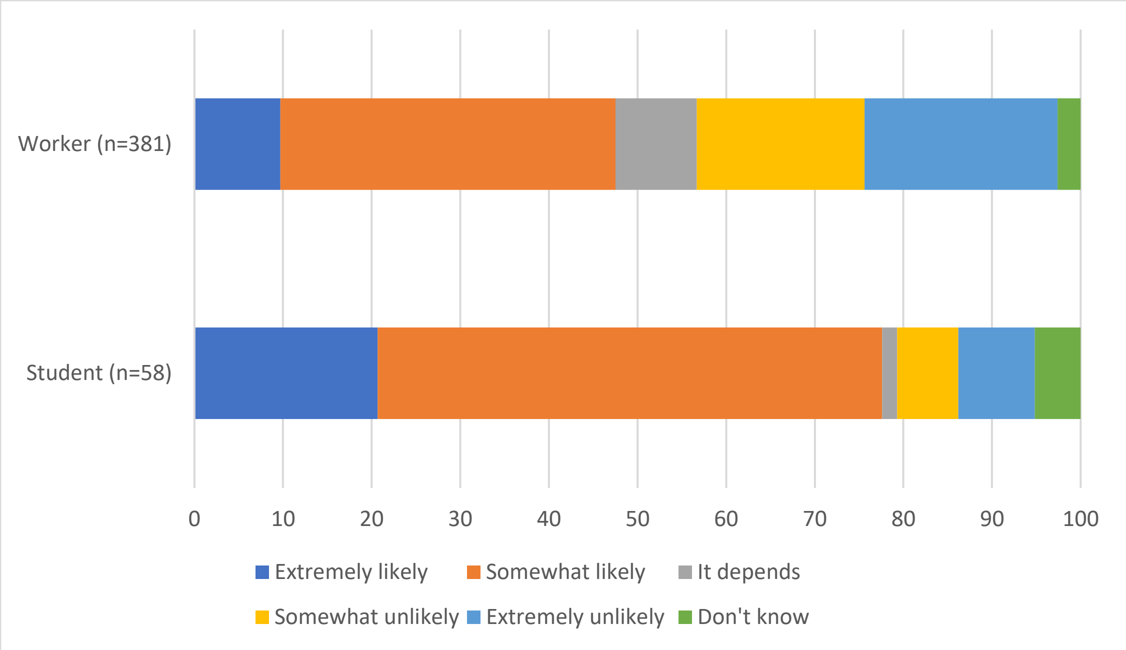


Figure 18: Participants' likelihood of reducing their car use

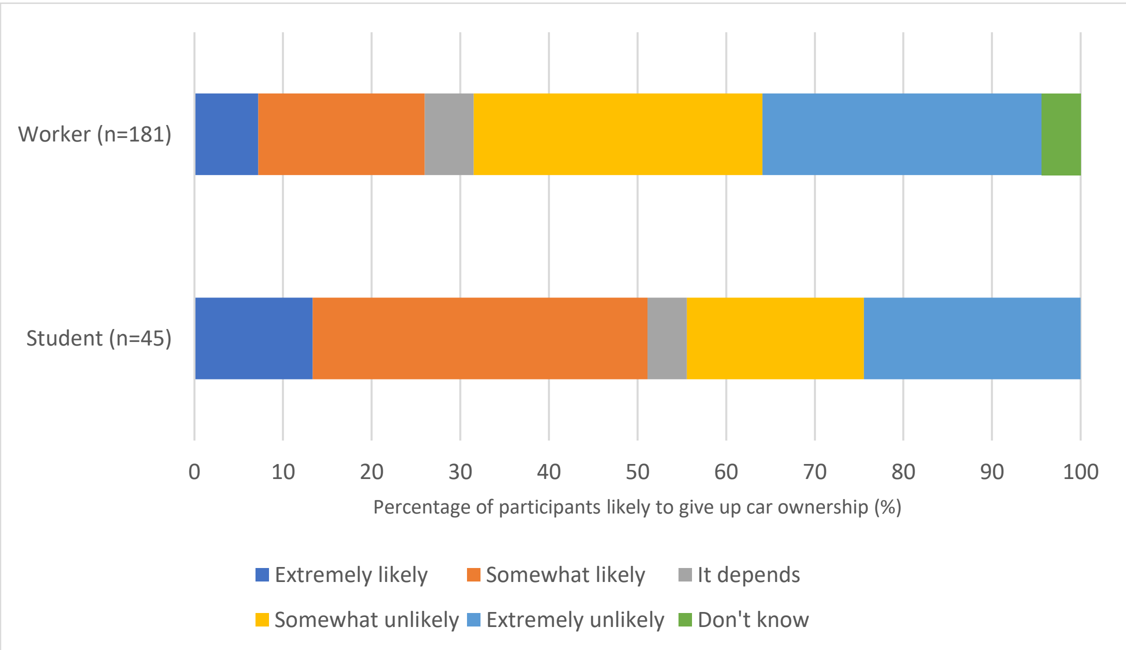


Figure 19: Participants' likelihood of giving up their car

Understanding participants choices through qualitative analysis

To understand early adopters' characteristics, Ho et al. (2020) proposed understanding the characteristics and features that would make MaaS appealing to the public. Following the eight choice tasks, participants were asked in an open-ended question to name and suggest features and characteristics which would make MaaS appealing for them. Some participants chose to mention a few additional features while others took the opportunity to explain why MaaS would not fit with their lifestyle. Using the qualitative software programme NVIVO 12 (QSR International Pty Ltd., 2020), the open text was coded into themes. Findings for each group are reported below.

The themes mentioned in both groups were consistent with results from a study by Polydoropoulou et al. (2020) from workshops with stakeholders and focus groups with end users in Budapest, Hungary and Greater Manchester, United Kingdom.

Workers' sample

Most of the participants commented on the cost of the subscription with many suggesting a cheaper price than the one shown in the stated choice experiment. Some participants claimed to be interested in MaaS if the price was lower than a train ticket while others stated to prefer to continue using their car believing the use of a private car was cheaper than public transport: "*It would have to be considerably cheaper than using my car and I don't believe it is*". One participant summarised the most talked about travel attributes, cost, and time, *"[MaaS needs to be…] Cheaper than running a car and quicker than public transport*".

Efficiency was the second most mentioned requirement for participants to consider using MaaS. Efficiency was defined as short waiting times and faster travel times with some referring to the need for reliable services since a few participants mentioned the unreliable train and bus services as deterrents: "*The travel time needs to be as good as car and be completely reliable*". To cater for the possible unreliable service, participants suggested the provision of taxis when trains are cancelled and for refunds when services are disrupted or late.

A few additional features or services that would make MaaS appealing were being flexible to cancel a subscription at any time, offline availability, customisation to include users most used travel modes and the inclusion of heavily discounted taxis and car hire, with discounts in the form of rewards from other sources such as food and retail. Other types of special prices for NHS workers were also mentioned with a few mentioning family discounts. The role of the household in making MaaS appealing needs to be considered when there is evidence that supports the common belief that MaaS could be a good substitute for the second household car but not the only car in the household (Smith et al. 2018, Ho et al., 2020). Thus, Ho et al. (2020) suggest the need for ongoing research to examine the demand for MaaS by households instead of individuals.

Overall, a few participants claimed they would never use MaaS because they preferred their car due to its' convenience and privacy and because they did not like using public transport in general. Nevertheless, some participants referred to the COVID-19 pandemic although this was only mentioned by a small number of participants. The pandemic was still evolving, and it might be one of the issues that would need to be addressed to attract users to use public transport as some remarked not feeling comfortable using public transport. For its potential adoption, some participants believed MaaS would need to be easy to use and navigate the different transport modes: "*easy to use interface and options to leave feedback on transport used*".

Student sample

As expected, the most commented feature of MaaS was the cost with the majority calling for a competitive price in comparison to other public transport modes, especially the train. Some participants mentioned the inclusion of a student discount with the use of student payment plans with possible rewards and incentives.

The second most mentioned theme by students was the added features that a MaaS subscription should have with many mentioning the inclusion of other transport modes such as Uber, carpool, guaranteed parking spaces, coach, and bicycle hire. Other added features that would make MaaS appealing would be the inclusion of discounts from retail outlets as well as "*discounted coffee shops while you wait to travel*".

A few participants did mention the need for the service to be flexible with "*different types of memberships"* and to be easy to use and register including customisation. Participants mentioned customisation to include frequently used transport modes in a subscription plan and unlimited travel with transport modes available 24 hours a day. Ultimately, a participant summarised the overall thoughts on MaaS by students "*As long as it offers me value for money. I don't mind. Everything about the concept is excellent, but I do have a budget to think about*".

5.3 Discussion

This research contributes to the growing literature on the potential adoption of MaaS using a stated choice experiment and the profiling of participants' preferences using current travel behaviours and patterns. The exceptionality of this study explored commuters' choice of a

MaaS product in the market together with other conventional modes of travel. Coefficients for the travel mode attributes and other sociodemographic and commute trip variables served to inform the potential preference for MaaS.

5.3.1 The role of attributes on mode choice

Preferences for characteristics related to participants choice of mode was as expected and consistent with previous studies: commuters prefer cheaper transport modes to get them to their destination faster with minimal travelling and walking time. As reported in other studies (Fu et al., 2019, De Guzman and Diaz, 2005), this study found travel costs playing a lesser role than travel times.

For both students and workers, the coefficient for walking time was the highest compared to the other travel time attributes and cost. This suggests participants ease of access to a transport mode influences their choice of transport mode (Yang et al., 2015, König et al., 2018). With reference to the student sample, Akar et al. (2012) found travel time was the most significant factor affecting university students' mode choice at Ohio University. A bus stop located within 0.5 miles from a student residence location was found to have a significant positive effect on students choosing the bus. Similarly, in a study by De Guzman et al. (2005) travel time was ranked first followed by convenience and then travel cost in a study to analyse the mode choice behaviour of university students in the Philippines. Hence, to improve the take up of public transport by student car commuters, Danaf et al. (2014) suggest decreasing bus travel time by the provision of shuttle services or taxi sharing and increase parking fees. Such strategies could be promising for students to switch from car to public transport, something which MaaS can offer with its multiple transport modes serving the first and last mile. In addition, MaaS aims to provide the user with the most efficient and fastest route to their destination (Jittrapirom et al., 2017).

The increase in walking time, in-vehicle time and cost decreases the utility of the relevant alternatives for both the student and worker sample. Similarly, König et al. (2018) found the attributes of walking distance, travel time and cost to affect the participant's choice behaviour towards a ridepooling system. For the student sample, the waiting time coefficient was not found to be significant but significant for the workers' sample. This suggests workers are more sensitive to time in comparison to students. The general belief is that workers have a higher value of time in comparison to students or non-workers (Danaf et al., 2014, Espino et al., 2007) and studies have shown how travel time is an important dimension in commuter travel decisions. Commuters are likely to be faced with timing requirements when arriving at work or at a commute stop and there are consequences associated with early or late arrival at the destination (Bhat and Sardesai, 2006) which is different when making a non-commute trip that is less time constraining (Choudhury et al., 2018). The results show workers are more sensitive to in-vehicle time compared to waiting time. The latter in public transport travel is often perceived negatively (Fan et al. 2016) and public transport users perceive waits for public transport vehicles to arrive as significantly longer than they really are. Meanwhile, in-vehicle time is generally perceived as taking roughly as long as it really does (Wardman, 2004). This unexpected result can be explained by the unexpected delays commuters face when being stuck in traffic especially in the city centre as explained by a participant who was interviewed for the study presented in Chapter 6. From the interviews and qualitative section of the DCE survey it transpired how participants make use of digital platforms which show real-time information such as the arrival and departure time of a transport mode, therefore participants are found they can control their waiting time but not the time taken in the vehicle.

Time sensitivity can also be explained by socio-economic variables such as the household income values of workers whereby Ciari and Axhausen (2012) found the value of travel time savings to be higher for persons with a higher income. Hence, in this study workers living in high-income households were more likely to choose MaaS over the bus and train. This can be explained by the purpose of MaaS to offer a single payment system integrating all existing mobility services to make a journey efficient and flexible with individual customisation services (Ho et al., 2020).

Ultimately, travel costs were also found to play an important role in the utilities of all alternatives for both students and workers. Travel cost was considered an important factor when using public transport modes (Mohammadzadeh, 2020) especially for students who are financially dependent on their parents, guardians, or loans (Whalen et al., 2013, Zhou, 2012). Students residing in their parents or guardian home and coming from low-income households were found to more likely choose the bus over the more expensive travel modes. To support this, results from the open-ended text asking participants what characteristics or features they would want to see in MaaS for them to consider its use, both students and workers mentioned cost. Most participants mentioned the need for a cheaper price and a subscription to offer rewards and discounts on retail outlets and private travel services such as taxis and car hire. Both groups mentioned how the cost of a MaaS subscription would need to compete with train tickets and be cheaper for them to consider subscribing. This is revealed in a study by Ho et al. (2020) where participants valued the convenience of MaaS apps, but they were not ready to pay for it, suggesting the need to include discounts to guarantee the widespread adoption of MaaS.

The results of this study are supported by previous studies showing both travel time and cost as the main factors influencing mode choice in students (Danaf et al., 2014, Eboli and Mazzulla 2008, Schubert et al., 2020) and workers (Alhajyaseen et al., 2020, de Palma and Rochat, 2000, Catalano et al., 2008, Bhat and Sardesai, 2006). Having travel costs playing a lesser importance than travel time attributes suggests that participants valued travel time and were willing to pay for reduced travel time. Similar results were found by Frei et al. (2017) who used a hypothetical flexible transit mode to study the shift away from car and traditional transit. The authors found the greatest shift to occur when reducing in-vehicle travel time for flexible transit and compensating the time saving with a price increase. Simulations suggested that users were willing to pay for this significant time saving (Frei et al., 2017). Hence, decreasing transit in-vehicle travel time or walking time and increasing the cost of public transport can still produce a shift to public transport.

The preferences for travel mode attributes were compared to the attribute non-attendance results (Table 38). Table 38 shows most participants reported to have always considered the monthly cost and never considered walking time when they were choosing their preferred monthly travel mode. However, in the random utility model (Table 33 for workers, Table 14 for students) walking time was found to have the highest coefficient for both groups. Nevertheless, the results of the attribute non-attendance should be interpreted with caution. There is evidence that not all individuals who claimed to have ignored an attribute really did (Carlsson et al., 2010). Thus, there is an inconsistency between what individuals declared and what they really did (Mohamad et al., 2018). Since a DCE involves a trade-off process among several alternatives each with its different attributes, participants may have been paying attention to one attribute but when deciding which alternative to choose another attribute aided their final decision. In this case participants were aware of the monthly cost but when deciding which alternative to choose, the amount of walking time was shown to have aided their decision.

5.3.2 Willingness to pay estimates

To examine how much participants were willing to pay for a reduction in travelling, walking, and waiting time the willingness to pay (WTP) estimate was used. The WTP for the in-vehicle time, walking time and waiting time attributes were estimated to understand participants' value of time using the coefficients of cost and the various time components. The value of time was the extra cost that a person would be willing to incur to save time (Train, 2009). Caution needs to be exercised when interpreting the WTP estimates since the attribute non-attendance results were inconsistent with the choice behaviour of the participants (Mohamad et al., 2018).

Accounting for attribute non-attendance behaviour in stated choice analysis is important as studies by Hensher (2006), Hensher and Rose (2009), Carlsson et al. (2010) and Scarpa et al. (2010) have shown that ignoring this behaviour can lead to biased WTP. The attribute non-attendance results in Table 38 are inconsistent with the WTP estimates in Table 40 since the majority of students and workers reported not considering walking time, however the WTP estimates show both groups willing to pay more for a reduction in walking time. Thus, Mohamad et al. (2018) claimed that the most ignored attribute should receive the lowest preference ranking in the estimated utility model, however, there is evidence that inconsistency exists between what individuals declare and what they really do. This suggests participants might have considered walking time more than the other attributes for certain choice tasks but given the most considered attribute was cost, participants may have had to make a trade-off between monthly cost, in vehicle time and waiting time in favour of walking time. Hence, the WTP estimates show participants would prefer to pay a price to lower the walking time than for the in-vehicle time and the waiting time.

The WTP estimates for both groups should be interpreted with caution. The value-of-time estimates were found to be higher when compared to findings of other studies. However, Ciari and Axhausen study on the use of carpool or carsharing found the WTP for walking time to reach a carsharing station was really high compared to corresponding car and public transport walking time values. Table 39 provides a number of studies and their WTP estimates. The cost attribute of this study represents a subscription which allows for a number of unlimited and unspecified number of trips per month, whereas the cost attribute of the other studies presented in Table 39 is represented by the cost of fuel per trip for the private car and the cost of a one-way ticket for public transport. However, the WTP estimates can be calculated per trip by assuming a number of trips per month such as 40 trips per month, i.e., an average 20 workdays a month multiplied by two trips per day. This means, the WTP estimates of this study need to be divided by 40 when being compared to other WTP estimates by other studies.

Table 39: Results of the willingness to pay estimate, found in mode choice studies using stated choice experiments, compared to the willingness to pay estimates for this study

Authors	**Study context**	**Willingness to pay estimates**	**Willingness to pay estimates range for this study per *monthly* subscription**
Arentze and Molin (2013)	Used a stated choice experiment to assess travellers' preferences in the Netherlands for multimodal networks.	10-minute travel time saving for train was €2.90 (£2.49) for a 20km distance 10 minutes walking time saving for train was €5.30 (£4.55)	10-minute travel in-vehicle time saving £27.50 - £37 10-minute walking time saving £37.60 - £52.50
Ciari and Axhausen (2012)	Studied the preference of travellers between carpooling and carsharing in Switzerland using a stated choice experiment	Walking time saving for car was CHF105.6 (£84.52) per hour Walking time saving for public transport was CHF 77.40 (£61.95) per hour Walking time saving for carshare was CHF360 (£288.14) per minute Travel time saving for car was CHF 163.70 (£131.02) per hour Travel time saving public transport CHF 50.76 (£40.62) per hour Travel time saving carshare was CHF 78.39 (£62.74) per hour	Walking time saving of £225.60 - £315 per hour Travel time saving of £165 - £222 per hour
Rojo et al. (2012)	Used a stated choice experiment to estimate the WTP for time savings in the bus service	Users WTP to reduce the bus journey by 1 hour was €8.35 (£7.17) Users WTP to reduce the car journey time by 1 hour was €13.68 (£11.75) Users WTP to reduce the train journey time by 1 hour was €18.14 (£15.58)	Travel time saving of £165 - £222 per hour

Danaf et al. (2019) explain how the main limitation of stated preference surveys of recording choices in hypothetical scenarios results in different types of biases such as inattentiveness, attribute non-attendance and incongruity with actual behaviour. Hence, participants WTP tends to be higher in stated preference than in revealed preference surveys. Polydoropoulou et al. (1997) studied the adoption of an advanced traveller information system and WTP and found participants unfamiliar with the attributes of the service to overestimate their WTP. The authors explain this as noncommitment bias. Thus, considering the choice experiment included the hypothetical product of MaaS, the WTP estimates have been overestimated. Hence, three studies that conducted a meta-analysis on hypothetical WTP were reported by Ready et al. (2010). All studies found values estimated from hypothetical responses were on average three times as large as actual WTP.

WTP estimate results in Table 40 shows workers exhibit a higher WTP for travel time savings compared to the student sample. This is similar to a study done by Espino et al. (2007) where travel time was found to produce more disutility for workers than for non-workers, which is reasonable given workers have less time available thus exhibiting a higher WTP for travel time savings.

Table 40: Willingness to pay estimates per monthly subscription

Attribute	**Willingness to pay (workers)**	**Confidence Level [Lower and Upper]**	**Willingness to pay (students)**	**Confidence Level [Lower and Upper]**	**Unit**	**Description**
In-vehicle time	-3.70*	[-4.80, -2.59]	-2.75*	[-4.88, -0.61]	£/minute	Value (£) which the user is willing to pay, per monthly subscription, to reduce the in-vehicle time by 1 minute
Walking time	-5.25*	[-7.29, -3.20]	-3.76*	[-7.62, 0.10]	£/minute	Value (£) which the user is willing to pay, per

Attribute	Willingness to pay (workers)	Confidence Level [Lower and Upper]	Willingness to pay (students)	Confidence Level [Lower and Upper]	Unit	Description
						monthly subscription, to reduce the walking time to nearby transit stops
Waiting time	-1.54*	[-2.45, -0.63]	-1.07	[-2.79, 0.66]	£/minute	Value (£) which the user is willing to pay, per monthly subscription, to reduce the waiting time at a transit stop before the next available service

*Significant at least at the 95% confidence level.

5.3.3 The role of individual characteristics in mode choice

The individual characteristics of travellers that are usually analysed for their potential influence on travel are age, gender, income, and car ownership (Zhou, 2012). These potential factors were tested for both groups as shown previously. However, participants usual mode of travel was of interest to see whether the trade-offs presented were enough to shift participants towards a different mode of travel than the one they are accustomed to. The results showed how workers who were car commuters were likely to stick to the private car, and bus and train commuters were also found to stick to their usual mode of transport over MaaS. This aligns with a study done by Frei et al. (2017) where participants who drove to work were significantly more likely to choose the car commute mode compared to participants who did not drive to work. Therefore, participants who were less likely to choose MaaS over their current mode of commute are considered to be satisfied with their usual modal choice (Fu et al., 2019) or otherwise they did not find the need for an additional transport mode, which MaaS offers, because their travel needs are being catered for by their current modal service. This was revealed in the qualitative section of the questionnaire in this study. Participants mentioned how they were not interested in a MaaS subscription because they were comfortable using one type of transport mode.

Participants who showed preference for MaaS were bus commuters who said to prefer MaaS over the train, and train commuters who said to prefer MaaS over the car and the bus. Therefore, commuters using the bus, or the train, and need to use an additional transport mode for certain journeys, recognise the value of a MaaS subscription. The latter can serve their first and/or last mile travel needs and help them plan door-to-door journeys using all the available transport modes. This result aligns with a study conducted by Caiati et al. (2020) who found participants travelling by public transport or train more willing to subscribe to MaaS.

Car ownership can influence participants preference of transport modes, and this was tested with the student sample since the majority of the workers sample were car owners. Student car owners were more likely to choose the car over MaaS and this is supported by previous mode choice studies on students (Limanond et al., 2011, Danaf et al., 2014). However, student car owners were found to prefer MaaS over the bus and the train with the highest negative coefficient for the bus. This shows how the service provided by current public transport systems may not be enough to shift car owners to use public transport, but a digital MaaS subscription may serve the travel needs of student car owners leading to a possible reduction in car use (Hörcher and Graham, 2020). Nevertheless, when participants were asked on their likelihood to give up car ownership, students more than workers reported to be willing to give up car ownership. Therefore, a digital service such as MaaS, which appeals to young adults, can satisfy travellers travel needs without the need to own a car.

Another factor found to significantly influence participants preference of transport mode was household income (Danaf et al., 2014) and type of residence. Students perceive MaaS as a premium with its on-demand transport modes (Alonso-Gonzalez et al., 2020), and therefore students living in low-income households and residing in their parents or guardian home were more likely to choose the bus over MaaS. In a study by Danaf et al. (2019) young participants from high income households were more likely to choose the new on-demand service. Therefore, the choice of the bus over any of the other, more expensive, transport options was expected in this study. Especially because MaaS would be highly more expensive than any discounted student monthly bus subscription. However, students who had a public transport subscription were more likely to prefer MaaS over the train. This is explained by the qualitative section of this study where participants mentioned the benefit of having multiple transport modes to cater for delayed and disrupted services with some suggesting refunds and the provision of an on-demand taxi service to continue with their journey in case of any disruptions. Interestingly, students who had a public transport subscription were more likely to choose MaaS over the private car. This augurs well for the reduction in car ownership and the continuation of public transport use. This is supported by experts in a study by Jittrapirom et al. (2020) claiming that early adopters of MaaS would be young, public transport and flexible transport users.

For the workers sample the least favoured form of transport similar to how student car owners responded was the bus. Only workers in part-time employment were more likely to choose the bus over MaaS, which was explained by part-time employees being slightly more sensitive to travel cost (Choudhury et al., 2018). Nevertheless, as shown with the student sample, income has an impact on mode choice for the workers' sample. High-income households were more likely to choose MaaS over the bus or train. This confirms how compared to other existing transport subscriptions, MaaS would need to be affordable for people living in low-income households especially when considering such households are more reliant on public transport services (Campaign for Better Transport, 2012). The likelihood of choosing MaaS by households with a high number of cars available was only found significant in relation to the use of the bus. The preference for MaaS over the bus with an increase in the number of cars owned by a household can be explained by participants affordability for alternative transport options. Nevertheless, this result was unexpected as studies linked participants in such households to choose the private car option (Yan et al., 2019, Bhat and Sardesai, 2006). In addition, Caiati et al. (2020) found participants having access to more than one car in their households were less likely to subscribe to MaaS. However, households with one car available had a higher probability of subscribing (Caiati et al., 2020). Thus, Johansson et al. (2019) suggest the best time to introduce MaaS would be when a car owned by a household needs replacement or the investment in a new car is being considered. These results show how a MaaS subscription has the potential to attract users from high-income households who are car owners to choose MaaS as an alternative to the current public transport subscription options (Caiati et al., 2020, Alonso-Gonzalez et al., 2020). However, the success of MaaS replacing the private car was found to be difficult in a MaaS pilot study conducted by Storme et al. (2020) in Belgium. The authors concluded that a MaaS subscription complements car possession and car use, thus the relationship between subscribing to MaaS and car ownership is much more complex than generally acknowledged (Storme et al., 2020).

Overall, MaaS operators may attract users through policies or programs that target specific users. Individuals comfortable with using digital technology to book and pay for travel services, who have a higher value of travel time and live-in high-income households are the potential MaaS users. Nevertheless, a cost reduction for a MaaS subscription and incentives from retail and private services such as taxis and car hire, while addressing the issue of making transport services accessible and safe for travelling, may increase the adoption of MaaS considerably. The findings could be helpful to address the needs and concerns of travellers by transport planners and service providers in the West Midlands.

5.4 Limitations and further research

This study was subject to some limitations. The idea at the beginning of designing this study was to investigate MaaS adoption with respect to overall mobility over a month acknowledging how people would be more likely to subscribe to MaaS if they could use it for multiple trip purposes. However, the scenario including both commuting and leisure trips would have complicated participants choice of alternative and attribute because studies have shown how travel time budget varies with trip purposes and is related to the requirement on punctual arrivals (Lo et al., 2006). Hence, to keep the study simple and focused, commuting was chosen as a trip purpose given how both workers and students need to travel a number of times during the week to work and study for which they would need to arrive at a certain time during the day.

It should be noted that the findings of this study are limited to the chosen scenario. Thus, results are restricted to the particular trip type of 7 miles commuting to a workplace or higher educational institution located in Birmingham City Centre. Further research could assess whether the findings are transferable to other trip types like shopping for essential goods or for long distance commutes. Moreover, this study had a substantial number of students commuting to Birmingham for educational purposes (58.4%) as well as participants in employment (45.2%). However, participants whose place of work or educational institution was located within the area referenced in the hypothetical scenario, the number of participants was quite low for students (17.7%) and workers (24.3%). Further research could provide scenarios that are customised to trips participants are familiar with.

Another limitation was the findings were based on stated preference data and though the stated preference survey was designed and pre-tested carefully, the findings can be subject to hypothetical bias and cognitive incongruence (Choudhury et al. 2018). For instance, even though participants were given a few questions to test their knowledge on what a MaaS subscription entails before proceeding to start the choice experiment, whether the participants correctly understood the MaaS concept and the meaning of its attributes, the actual comprehension rate is unknown (König et al., 2018).

As discussed in mode choice studies researchers report how attitudes and perceptions influence mode choice. Thus, the preference for MaaS and any other travel option, may be significantly affected by the attitudes and perceptions of the respondent. Such subjective attributes can be considered alongside mode attributes. Subjective attributes can be identified from a literature review and a focus group would validate the results of the literature review. This exercise would help to identify and include attributes relevant to the subject and to exclude irrelevant attributes. Appropriate terms for the attributes would need to be specified to correspond to the actual vocabulary of the prospective participants (Kløjgaard et al., 2012). Because of data limitations, it was not possible to incorporate these effects in the present study but testing them can be an interesting direction for future research. In addition, the stated preference survey included only cost, in-vehicle time, waiting time and walking time. Extending the choice spectrum even further to include departure time, occupancy choice and route, is likely to provide more robust results. However, this would more likely amplify the time and costs needed to design the survey and collect the data.

With regards to the collected sample of participants, a common limitation of online surveys lies in the self-selection of participants (König et al 2018). To name one bias, the sample consisted of a higher share of females than the overall female population employed in the West Midlands.

In conclusion, travellers' needs are immensely heterogeneous and understanding how heterogeneous travellers' value attributes of mode alternatives is at the core of travel demand forecasting. As the number of available modes continues to increase, estimating the response of travellers to these new modes is critical to planning future infrastructure (Frei et al., 2017). Nevertheless, further research would be beneficial to assess the type of MaaS subscriptions commuters in the West Midlands prefer, thus replicating studies by Caiati et al. (2020), Ho et al. (2018, 2020) and Matyas and Kamargianni (2019), to test users' preference of MaaS bundles for the West Midlands.

Chapter 6 Mode Choice during the University-to-Work Transition

The previous empirical chapters identified factors influencing mode choice using psychological and travel attributes. Cost, time, access to public transport services and the opinions and behaviour of significant others were found to influence participants' mode choice. However, the underlying issues explaining why such factors influence mode choice has not been examined. Individual travel behaviour is complex and as shown in the previous chapters, in the case study area of Greater Birmingham, students are predominantly public transport users and workers are private car users.

As discussed in the literature review (Chapter 2) the life transition from university – to – work has been found influential in shifting graduates from public transport towards the private car. The aim of this chapter is to understand the underlying issues of mode choice during this life stage transition and to identify personal and mobility factors influencing participants' travel choices.

The research question for this chapter was:

- **RQ3:** Which factors influence young adults' mobility decisions as they transition from university education to the workforce?

6.1 Methodology

As the quantitative surveys in the previous empirical chapters restricted the question-and-answer frame – meaning that potentially critical information might not have been captured – the qualitative phase was purposefully conducted without a stricter structure. The aim of this study was not only to elicit participants capability, opportunity, and motivation influences on mode choice but also to understand the role of MaaS as a sustainable travel tool for participants, in light of current travel policy measures in Birmingham. As explained by Bamberg et al. (2011) using past travel choice contributes to the prediction of future behaviour, only if circumstances remain relatively stable. Hence, the implementation of the CAZ and Traffic Cells Initiative in Birmingham (Chapter 3 Section 3.2.2) and the potential availability of MaaS, are anticipated to influence participants future travel choice.

The questions included in the interview focused around three priority areas where in-depth qualitative insights could complement the findings from the quantitative results. The three areas were to:

(1) Understand how the capabilities, opportunities and motivation behaviour of graduate employees shaped their mobility decisions during their university – to – work life course.
(2) Introduce the concept of MaaS and seek opinions, comments, and suggestions for the potential role of MaaS as a sustainable travel tool for participants.
(3) Discuss the potential of MaaS in the current changing climate of commuting because of the COVID-19 pandemic and the Birmingham CAZ policy launched in June 2021

The interviews were structured around the question topics listed in Table 41 and a detailed copy of the interview guide can be found in Appendix C. The interview guide was divided into four sections. The first three sections included questions pertaining to the COM-B model. The fourth and final section focused on the role of MaaS and the impact of the travel policies in Birmingham on participants' mode choice.

Table 41: Topics covered in the semi-structured interviews

Interview guide section	Topics	Aim of the section
1	Participants' experience commuting to university and to their place of work. Transport modes available and attained during the transition.	Understand how changes in the life course of graduate employees impacted their travel choices.
2	Environmental attitude towards commuting. Awareness of sustainable travel modes from university and employment.	Impact of environmental attitudes and travel campaigns on travel choices.
3	Willingness to use shared mobility services. Social influence on using shared mobility.	Understand participants willingness to use shared mobility services which form part of a typical MaaS subscription. In addition, identify any influences from family and friends in using such services. Evaluate the willingness and social influence of participants on their travel choices.

Interview guide section	Topics	Aim of the section
4	Introduce the concept of MaaS. Evaluate participants first thoughts and if it fits their travel needs.	Gather first thoughts on the appeal of MaaS in light of transport policy measures in Birmingham and possible effects of the COVID-19 pandemic.

6.1.1 Semi-structured interview guide

For a detailed understanding of the behaviour, the TDF domains were mapped onto the components of the COM-B model (Cane et al., 2012). The TDF domains helped to breakdown the COM-B model components into manageable themes which were linked to personal factors and mobility conditions not captured by either the TPB or the DCE.

The lack of travel behaviour studies using the COM-B model and TDF domains made it more challenging to interpret the TDF domains. Thus, the step-by-step guide provided by Atkins et al. (2017) and the example interview questions provided by Michie et al. (2014) were used to compile the interview guide. When compiling the interview questions some were found to either overlap or not clear as to how they relate to the behaviour under study. The TDF domains for 'Behavioural Regulation', 'Optimism' and 'Goals' were either found to overlap with other TDF domains or found to be incomprehensible in relation to mobility decisions taken by young adults as they transition from university to the workforce. Behavioural regulation implies 'anything aimed at managing or changing objectively observed or measured actions', this would refer to the smartphone applications displaying travel and traffic data. Travellers can track their journeys using specific travel applications. The use of such services is covered in the domains pertaining to knowledge and skills, therefore behavioural regulation was found to overlap with other domains and was not included. Optimism refers to the belief that "things will happen for the best or that desired goals will be attained" (Michie et al., 2014). This example is not clear when being interpreted for mode choice because the behaviour under study involves participants making a decision rather than leaving it to chance. Therefore, the 'Optimism' domain was not included due to it being ambiguous in relation to the behaviour under study. According to Michie et al. (2014) the 'Goals' domain is 'mental representations of outcomes or end states that an individual wants to achieve'. This was found to be similar to the Intentions domain for the purposes of travel behaviour defined as 'a conscious decision to perform a behaviour or resolve to act in a certain way'. Participants were asked about their travel choices and what led them to such decisions, hence having a goal to use a certain transport mode can overlap with the intention of using particular transport modes. Thus, for this study the 'Goals' domain was not included. With the decision to remove the TDF domains of 'Behavioural Regulation', 'Optimism' and 'Goals', using the remaining TDF domains made it possible to setup more comprehensible questions for the participants to understand and provide valuable answers for the study.

When compiling the interview questionnaire, the TDF domains were found to be constrictive which can lead participants to provide specific comments about the topic (Lambe et al., 2020). To avoid this, interview questions were set up guided by previous qualitative travel behaviour studies. This allowed for opinions to arise naturally rather than being prompted by more narrow questions about individual domains of the TDF (Lambe et al., 2020).

The first three sections of the interview included questions pertaining to the COM-B model which were guided by the example interview questions of Michie et al. (2014) as shown in Table 42. When using interviews Michie et al. (2014) advises researchers to:

- Ask open ended questions to promote exploration of ideas rather than yes/no responses,
- Be cautious when asking direct questions about influences on current behaviour because of social desirability and professional identity biases and
- Ask questions in relation to specific instances of current or recent behaviour and in relation to specific contexts (where and when).

A few interview questions included retrospective qualitative data which is considered sufficiently reliable to explore travel behaviour in the context of life course (Lanzendorf, 2003). The first section of the survey included questions on the participants choice of travel mode when they were at university and how this might have changed as they transitioned into their first graduate job. This included questions on what type of travel mode the participant used and why, the transport modes available at the time and their travel experiences. Participants were also asked reasons for having – or not – having a driving licence. The second section of the interview explored the participants awareness of sustainable campaigns, both at the university they used to attend and at their workplace.

The third section introduced the ideas of shared mobility services: carsharing, bike sharing; ridesharing and electric scooters (e-scooter). It is important to note that in Birmingham and the West Midlands, provisions of carsharing, ridesharing, bike sharing, and e-scooters are provided. A list of carsharing platforms is provided by the local council naming Co-Wheels

Birmingham car club, Enterprise Car Club and Easy Car Clubs as providers. Ridesharing is provided via the companies Liftshare, BlaBlaCar and Uber. The availability of bike sharing platforms in the West Midlands has been inconsistent over the past few years. Nextbike was launched in 2019 however a year later stopped operating in the West Midlands and were replaced by the operator of London's famous Santander Cycles. The bicycle hire scheme was rolled out across parts of the West Midlands between March and July 2021, with a trial period in February 2021 in Sutton Coldfield, Birmingham. Thus, participants were not expected to show knowledge about the new bicycle hire scheme but could show knowledge of bike sharing schemes from visiting other places. One of the recent additions to the sharing mobility services was the e-scooter. The Swedish operator Voi launched e-scooters for hire across Birmingham, Coventry, and West Bromwich. The benefit of using Voi e-scooters compared to a privately owned e-scooter is that the person can use public roads to ride the e-scooter. Nevertheless, anyone riding an e-scooter would need to have a full or provisional UK driving licence. The e-scooters were launched in September 2020 as a trial in Birmingham but since then they expanded to include other areas in the city. With reference to the shared mobility services available, participants were asked whether they had seen such services, what they thought of personally using these services and whether they knew any friends or family who used such services. This section concluded by asking participants what they thought their friends and family would say about them using shared mobility services.

Table 42: List of interview questions created from the COM-B components and TDF domains following example interview questions provided by Michie et al. (2014)

COM-B components	TDF Domain	Example Interview questions (Michie et al., 2014)	Interview Questions
Physical capability	Skills	Do you know how to do *x*?	Do you have any long-term physical or health issue that limits your ability to travel?
Psychological capability	Knowledge	Do you know about *x*?	What type of transport modes did you have available where you live? There is this idea of shared car and taxi rides or shared and pooled commuting, have you seen these services around?
	Cognitive and interpersonal skills	Do you know how to do *x*?	What was your experience using {transport modes}?

COM-B components	TDF Domain	Example Interview questions (Michie et al., 2014)	Interview Questions
	Memory, attention, and decision processes	Is *x* something you usually do?	How would you describe your commute and what was your experience? How much do/did you plan your journey before you set off?
	Behavioural regulation	Do you have systems that you could use for monitoring whether – or not – you have carried *x*?	Not applicable
Physical opportunity	Environmental context and resources	To what extent do physical or resource factors facilitate or hinder *x*?	Was there a time when you had to change your commute? Did you try using other transport modes? What was your experience using (transport mode)?
Social opportunity	Social influences	To what extent do social influences facilitate or hinder *x*?	What would your family and friends think about you using public transport? Do you know anyone who uses public transport and shared mobility services?
Reflective motivation	Social/ professional role and identity	Is doing *x* compatible or in conflict with professional standards/identity?	Can you remember any greening actions or sustainability campaigns that the University used to organise and promote? With reference to your current place of work, have you received any specific environmental training?
	Beliefs about capabilities	How difficult or easy is it for you to do *x*?	Did you try using other transport modes? How easy or difficult would it be for you to reduce your commute by car?
	Optimism	How confident are you that the problem of implementing *x* will be solved?	Not applicable
	Beliefs about consequences	What do you think will happen if you do *x*?	Did you try using other transport modes?

COM-B components	TDF Domain	Example Interview questions (Michie et al., 2014)	Interview Questions
	Intentions	Have they made a decision to do *x*?	In the survey you said you have a driving licence. Can you tell me when you got your driving licence and what made you decide to get a driving licence? In the survey you said you do not have a driving licence. Can you tell me what would make you decide to get a driving licence? How important was transport in your decision about where to live and work?
	Goals	How much do they want to do *x*?	Not applicable
Automatic motivation	Reinforcement	Are there incentives to do *x*?	Can you remember any greening actions or sustainability campaigns that the University used to organise and promote? With reference to your current place of work, have you received any specific environmental training?
	Emotion	Does doing *x* evoke an emotional response?	What was your experience using (transport mode)?

The final section of the interview introduced the participants to the concept of MaaS and the CAZ and Traffic Cells Initiative in Birmingham City Centre. First, participants were introduced to the concept of MaaS and shown an infographic while the researcher explained how MaaS works and how the concept compared to existing transport mobile applications. Participants were then asked if they had heard of the concept and what their initial thoughts about the digital planner were. They were then prompted to name any specific app features or payment methods as the most important features and factors that they would expect MaaS to have. To understand how willing the participant would be to use MaaS, participants were asked to say how MaaS would fit their travel needs or otherwise and what would make MaaS appealing for them to consider using it.

Following the discussion on MaaS, the conversation moved on to introduce the planned restriction measures in the city centre of Birmingham. Participants were asked if they knew about the CAZ and whether they had seen the Traffic Cells Initiative map. Participants were asked what they thought about the new restrictions and how it would affect their work and non-work commute. Given this scenario, participants were asked whether MaaS could be a potential mobility tool for travelling into the city centre.

The interview moved on to questions exploring how the pandemic and travel restrictions had affected participants usual day to day travel and what they thought in the long-term commuting would be like. To gauge the respondent's thoughts and self-motivation of being environmentally proactive in their choice of travel mode, the interview concluded with a general question asking participants what they thought was the impact of transport on the environment. Before ending the interview, participants were asked if they wanted to discuss or share information with the researcher about a topic related to transport that they believed was important.

Pilot interview

Three pilot interviews were conducted with colleagues and friends. Piloting the interview guide served to practice asking the questions in a setting similar to an online interview using Microsoft Teams. The pilot phase also served to ensure the wording of the questions were understood by the participant and that they relayed the information that the researcher was after. Practising the interview allowed the researcher to test whether 45 minutes was sufficient time to complete all the questions in the interview guide while holding an effective dialogue with the interviewee.

6.1.2 Participant recruitment procedure

A mix of convenience, purposive and snowball sampling was used to recruit participants. Potential research participants were purposefully recruited using Facebook community groups located in the West Midlands. A call for research participants was promoted looking for university graduates who graduated from a UK university within the last 3 years and were residing and working in the West Midlands. Potential participants interested in taking part were asked to fill in a short pre-interview questionnaire (Appendix D) to assess their demographic characteristics as well as their travel behaviour and certify their eligibility for the study. The software Qualtrics was used to design, construct, and implement the questionnaire. The answers from the questionnaire enabled the researcher to customise the interview questions.

Researchers often debate how many participants to sample with some suggesting the number of interview participants should be determined when saturation occurs. The National Centre for Research Methods published a review paper asking experts in the field how many interviews does one need when conducting a piece of qualitative research (Baker and Edwards, 2012). Baker and Edwards (2012) concluded that the answer is "it depends" (p.42), with some experts identifying outside determinants such as the time and financial budget available for the project. Several experts in Baker and Edwards (2012) do offer what the sample size should be. Adler and Adler suggest between a dozen and 60 with 30 being the mean. On the other hand, Bryman argues how the heterogeneity of the population is likely to influence the sample size quoting Guest et al. (2006) who conducted interviews with women in two West African countries and found saturation was attained after 12 interviews. Guest et al. (2006) conducted an experiment using codebooks from an earlier qualitative interview study and argued that 12 interviews suffice for most researchers when they aim to discern themes concerning common views and experiences among relatively homogenous people. Ultimately, several experts suggest to stop adding cases when one is no longer learning anything new and therefore one would have reached saturation.

The people that showed interest in being participants in the study were filtered to ensure they fit the participant criteria needed for the study. Taking into consideration the time and funding constraints, a total of 27 people were interviewed.

6.1.3 Data analysis

The qualitative analysis tool NVIVO 12 (QSR International Pty Ltd., 2020) was used to analyse the transcripts thematically. Thematic analysis is considered as the foundational method for qualitative analysis as it allows the researcher to identify themes and patterns in the data (Braun and Clarke, 2006). As a hugely popular analytic method, Evans (2018) suggests using thematic analysis when examining peoples meaning and significance of their experiences constrained and enabled by their material or social contexts. In this study the interview transcripts were analysed thematically using a deductive approach to report the subthemes related to each TDF domain. The TDF was used as the coding framework to allow for a more fine-grained analysis of factors influencing mobility decisions (Lambe et al. 2020, Kam et al., 2020). The qualitative results from the sections introducing MaaS and the CAZ were analysed thematically looking for factors influencing participants and opinions on their potential use of MaaS. Quotes were selected from the transcripts to illustrate each subtheme and can be found in Appendix E. Participant ID codes were not presented against each quotation to avoid the identification of any individuals. Quotes were reported verbatim except for minor additions (in square brackets) to improve the readability (Gainforth et al., 2016).

6.2 Results and analysis

6.2.1 Sociodemographic characteristics of study participants

A total of 50 people completed the pre-interview survey, of which 27 were available to be interviewed. Table 43 shows the socio-economic characteristics and household composition of the participants. These results were collected during the pre-interview survey which participants filled in to assess their eligibility for the study.

Three of the participants (two females, one male) were mature students with children under the age of 18. The inclusion of mature graduate students looking after young children provided a different perspective to the travel needs and experiences compared to the other graduates. The average age of the mature graduate students was 35 years old and the average age of the 24 young graduates was 24 years old. The characteristics of the sample in the study were compared to the Higher Education Graduate Outcomes Statistics UK 2017/18 (HESA, 2020). The results show most graduates in full-time employment in England were female and the age group with the highest number of graduates in full-time employment were between the ages of 21 and 29 years. The sample of interviewees were mostly female and between the ages of 21 and 37 (n=17), with the majority less than 25 years old. Even though the sample reflects the population of graduates in full-time employment in England, it should be emphasised that the purpose of the qualitative research is not to gain a representative sample. The approach taken was to reach point of saturation where the collected data began to provide little, if any, new insights on the research questions.

With regards to the work status of the participants, 23 participants reported to be in full-time employment while four participants said they were part-time employees. In terms of household income 13 participants were living in middle income households (>=£20,000<=£44,999); six participants were living in high income households (>=£45,000); and seven participants were living in low-income households (<=£19,999). Only one participant did not declare what their household income before tax was. Participants were not asked exclusively with whom they lived with, but during the interviews all participants mentioned their living situation in passing. The three mature graduate students lived in a household with their significant others and children. Some participants (n=13) said they lived with their partners, six participants said they still lived with their parents and another five participants said they rented on their own or with housemates.

Table 43: Sociodemographic, socio-economic, household composition, and employment status of interviewed participants

Code	Gender	Age	Work status	Household with young children	Household income (before tax)
P01	Female	37	Full-time	Yes	£25,000 - £29,999
P02	Female	24	Full-time	No	£25,000 - £29,999
P03	Male	33	Full-time	Yes	£55,000 or more
P04	Female	23	Full-time	No	£15,000 - £19,999
P05	Female	24	Part-time	No	£55,000 or more
P06	Male	27	Full-time	No	£25,000 - £29,999
P07	Female	23	Full-time	No	£20,000 - £24,999
P08	Male	26	Full-time	No	£35,000 - £39,999
P09	Female	21	Part-time	No	less than £15,000
P10	Female	25	Full-time	No	£20,000 - £24,999
P11	Male	25	Full-time	No	£45,000 - £54,999
P12	Female	23	Full-time	No	£35,000 - £39,999
P13	Female	23	Full-time	No	£30,000 - £34,999
P14	Female	23	Full-time	No	£20,000 - £24,999
P15	Female	25	Full-time	No	£25,000 - £29,999
P16	Male	24	Full-time	No	£15,000 - £19,999
P17	Male	24	Full-time	No	£45,000 - £54,999
P18	Female	35	Full-time	Yes	£15,000 - £19,999
P19	Female	22	Full-time	Yes	£15,000 - £19,999
P20	Female	25	Full-time	No	£40,000 - £44,999
P21	Female	23	Full-time	No	£35,000 - £39,999
P22	Female	23	Part-time	No	Prefer not to say
P23	Female	23	Full-time	No	£25,000 - £29,999
P24	Male	24	Full-time	No	less than £15,000
P25	Male	24	Full-time	No	£45,000 - £54,999
P26	Male	22	Part-time	No	less than £15,000
P27	Male	27	Full-time	No	£55,000 or more

6.2.2 Travel behaviour characteristics of study participants

Before delving into the travel behaviour characteristics of participants, it is important to note that at the time of the interviews, the UK Government had put in place travel restrictions as a result of the global COVID-19 pandemic. The working population was urged to work from home where possible and participants working commutes were disrupted. Data was collected on work commutes pre-COVID and, if any, during COVID. Commutes during COVID are presented and discussed in Section 6.3.7. The following results and discussion relate to pre-COVID travel unless stated otherwise.

Most of the interviewees had a valid full driving licence (n=20). Participants got their licence either before starting university (n=11) or during their time at university (n=8) with one participant after leaving university. In terms of owning their car, participants (n=11) said they got their car with the help of family members while others (n=7) bought their car after they started working. Only three participants did not own a car but said they had access to someone else's car.

Table 44 provides an overview of the participants university commute compared to their work commute. With regards to participants commute to their university campus the majority (n=20) either walked, rideshared, or used public transport. Only six participants said they used their car. Another participant said they used their car halfway to drive to the train station and then took the train and another participant said they were chauffeured by a family member. Some participants said they drove to campus occasionally when they had to carry instruments or planned to stay late because of extracurricular activities.

As part of their degree, seven participants had work placements. Four participants used public transport with one of the participants managing to get their driving licence during the placement and switching to driving. The switch was said to be motivated by the 1.5hr bus journey and early wakeup call. Moreover, the participant said this was possible because they were provided with a car by their family members. Despite having a car, the participant did not choose to keep the car when they went back to university because of the lack of parking spaces and not finding the need for a car given they lived a 5-minute walk away from campus.

As participants transitioned from university education to the workforce the majority were found to have changed their choice of transport mode except for six participants. Two participants kept using the bus, another two participants kept using their personal car, one participant continued to commute on foot and one participant continued to drive to the train station and catch the train. The participants who changed their travel mode, the majority chose to drive to work (n=13) followed by public transport (n=10). Three participants used to walk to work, and one participant alternated between cycling and driving. Differences between participants commute to campus and commute to other study purposes such as work placements, lectures off campus and volunteer research work are provided in Table 44. References to such travel behaviours are important because participants cited such activities to have aided them in their travel choices.

As discussed in Chapter 2, Section 2.2, residential relocation can lead to a change in travel behaviour. Participants were asked if they had relocated within the last three years to identify any travel behavioural choices related to residential relocation. The three mature graduate students said they did not relocate and said they had always commuted from their family home to university and work. The seven participants who did not relocate said they were still living with their family or in the same location because the location remained convenient for them after graduating. Most of the participants (n=17) said they relocated out of convenience to either be close to their place of work or close to a public transport station. Nine participants who drove to work explained they relocated to have a shorter commute. Other factors explaining residential relocation but not related to the commute to work included finding cheaper accommodation, moving in with a partner and moving out of a student area of accommodation.

Overall, during the interviews a variety of reasons for these changes in commute mode were identified. Each participant expressed and explained why and how they chose which transport mode to use when commuting to university and to their place of work. The remainder of this section will explore the barriers, facilitators, and motivators for participants' travel choices. Emergent themes shaped by the domains of the TDF framework and COM-B model are discussed in the next section.

Table 44: Participants' choice of commute mode, showing how mode choice differed from being a student to being employed

Code	University commute	Workplace commute (pre-pandemic)	Driving Licence	Car Status	Household Relocated within the last 3 years
P01	Bus	Bus	Yes	Access to someone else's	No

Code	University commute	Workplace commute (pre-pandemic)	Driving Licence	Car Status	Household Relocated within the last 3 years
P02	Walk	Train	No	Neither own nor have access to someone else's	Yes
P03	Cycle/Bus /Drive	Drive	Yes	Own	No
P04	Walk (Bus for work placement)	Walk/Taxi	No	Neither own nor have access to someone else's	No
P05	Train	Walk	No	Access to someone else's	No
P06	Walk	Drive	Yes	Own	Yes
P07	Walk (Drive to lectures off campus)	Drive	Yes	Access to someone else's	Yes
P08	Walk	Train	Yes	Own	No
P09	Bus (Rideshared for work placements)	Drive	Yes	Own	No
P10	Bus and Train	Walk/Rideshare	No	Access to someone else's	Yes
P11	Drive and Train	Drive and Train	Yes	Own	No
P12	Walk	Walk	No	Access to someone else's	Yes
P13	Walk (Bus/Drive for work placements)	Drive	Yes	Own	Yes
P14	Walk (Bus for work volunteer)	Drive	Yes	Own	Yes
P15	Bus (Bus for work placement)	Drive	Yes	Own	No
P16	Rideshared/Drive (Drive for work placement)	Drive	Yes	Own	Yes
P17	Walk	Train	No	Neither own nor have access to someone else's	Yes
P18	Drive	Drive	Yes	Own	No

Code	University commute	Workplace commute (pre-pandemic)	Driving Licence	Car Status	Household Relocated within the last 3 years
P19	Bus	Bus	No	Neither own nor have access to someone else's	Yes
P20	Walk (Bus and Train for work placement)	Bicycle (Only drive for meetings)	Yes	Own	Yes
P21	Drive (Walk for work placement)	Bus	Yes	Own	Yes
P22	Private Car passenger	Drive	Yes	Own	No
P23	Walk/Bus	Train	Yes	Access to someone else's	Yes
P24	Walk/Cycle/Drive	Drive	Yes	Own	Yes
P25	Walk	Train	Yes	Own	Yes
P26	Walk/Cycle/Drive	Drive	Yes	Own	Yes
P27	Bus/Rideshared/Drive	Drive	Yes	Own	Yes

6.2.3 Domains influencing young adults' travel choices

To understand which factors influenced participants' travel choices during their life stage transition, participants were asked about their past commute to university and their commute to work. This was done by asking questions designed to reflect the TDF domains which represent the different components of the COM-B model. Using thematic analysis, sub-themes linked to the TDF domains were elicited from the interview transcripts. Each sub-theme is presented below under their respective TDF domain and COM-B model component.

As suggested by Atkins et al. (2017) findings of TDF-based interview studies are reported in tables including quotations, emerging themes, and frequency counts. Appendix E provides a table with the quotations, frequency counts and emerging themes for each of the TDF domains and COM-B model components.

Capability dimension

The capability dimension refers to the physical and psychological capability to perform the behaviour.

Physical capability

Defined by Michie et al. (2014, p.63) as “physical skill, strength or stamina”.

Skills

Skills is “an ability or proficiency acquired through practice” (Michie et al., 2014, p.88). In relation to travel choices, participants were asked if they had any long-term physical or health issues which limits them from using different transport modes. None of the participants reported to have a physical disability, therefore this domain was not found to have a strong impact on participants’ travel choices.

Psychological Capability

Defined by Michie et al. (2014, p.63) as “knowledge or psychological skills, strength or stamina to engage in the necessary mental processes”.

Knowledge

Knowledge is “an awareness of the existence of something” (Michie et al., 2014, p.88). In relation to travel choice, knowledge of existing transport modes was questioned. All participants had a relatively good knowledge of the public transport services available to them both when they were at university and at their place of work. In terms of knowledge on other transport modes such as carsharing, bike sharing and electric scooters, most participants (n=21) were aware of at least one.

More than half of the participants (n=21) said they had seen the e-scooters and only two participants said they had seen carsharing platforms in the UK. However, they had used the service only outside of the UK. A number of participants confused rideshare with carshare, however on further questioning participants were most of the time referring to ridesharing. Carsharing was something participants did when travelling to a different country and rented a car. Participants who rideshared (n=7) explained how they would rideshare with friends and family but not in a formal way. Similarly, with bike sharing, only three participants recalled seeing bike sharing platforms in London with only one making reference to a bike sharing company in the West Midlands (Nextbike).

"[Carsharing] I've actually used them in Spain but not in the UK …I've seen them in the UK as in they [the company] have the same website … but there's just not a lot of choice in the UK because people are not doing it…[e-scooter] yes I've seen it more and more in the last 2 months … I think they are owned by the council as well so it's like the idea of shared bike you just pay and then you use it and then you park it wherever you go"

All participants showed how their knowledge of existing transport modes stemmed intrinsically when they personally needed to look for travel options. This was mainly found to occur when participants were students and prevalent for participants who did not own a car. Hence, three participants mentioned how it took them a few months or years to find the best way possible to travel to their university or to find someone who they could rideshare with. One participant argued how universities should provide students, preferably during the induction day, with information or a personalised travel plan on how to travel to university efficiently. Such information would be beneficial for students who do not have a driving licence and depend on public transport to get to university.

Similar to how university students are given an induction at the start of their university course, new employees at their place of work are also given an induction. The induction at the workplace usually consists of being shown around the offices and informed about office house rules. Participants were asked if they had been given any information on their travel options to work or commuting schemes such as the cycle to work scheme or the train corporate scheme. Only eight participants knew about travel schemes offered by their workplace either from colleagues or because of their own initiative to look on their employer's website and ask about the schemes. When asked if they had ever been given environmental training or an induction on sustainable commuting at their workplace, none of the participants could recall ever being given such information and most of the environmental practices at their workplace revolved around recycling and reducing the use of paper. Nevertheless, some participants (n=7) expressed how the promotion of using alternative transport modes to discourage staff from driving would be helpful, however the employer was always found to dictate the outcome.

"there are lots of drives to get people to buy bikes and your employer can pay part of that … and that's never been discussed in my company. I did ask somebody in my company about whether we could do that [cycle to work scheme] and they've sort of said they've not heard

anything about it so it would be nice if there was help to get people to cycle maybe or to discuss sharing cars that kind of thing"

Cognitive and Interpersonal Skills

Cognitive and interpersonal skills is "an ability or proficiency acquired through practice" (Michie et al., 2014, p.88). In relation to travel choices, participants were asked to describe their experience of commuting which could have influenced their future travel choices.

Participants who used public transport (n=11) to travel to university referred to the use of a smartphone travel app to check for travel times. Another participant said how easy it was to use a smartphone travel app to order a taxi or an Uber and pay for it via the app. The skill of knowing how to use a mobility app was valuable to participants because it helped them navigate public transport services. In particular, two participants remarked how they could immediately book a taxi or Uber when the bus or train they were waiting got cancelled or delayed allowing them to continue their journey with the least disruptions.

The acquisition of skills was usually through knowledge and trial and error. For three participants finding the most efficient way of travelling to their university took months of practice. Using different buses and bus routes led them to learn which was the best bus route for them when travelling to university. This process made participants more confident when using public transport. Participants (n=7) who lacked experience using public transport said they were less confident using such services with some explaining the lack of information of how to use such services to be a key factor. Consequently, the lack of information on how to use the e-scooters made it difficult for participants (n=6) who wanted to use the service.

"I don't think they're very well kind of publicised how to use them [e-scooters] so I know that I think you have to download an app but as a resident of Birmingham I don't know which app it is, I don't know how it actually works, so that's made me more hesitant to give it a go"

Memory, attention, and decision processes

Memory, attention, and decision processes is "the ability to retain information, focus selectively on aspects of the environment and choose between two or more alternatives" (Michie et al., 2014, p.88). In relation to travel choices, memory, attention, and decision processes were questioned in relation to participants typical commute pattern and habitual behaviour. Participants (n=11) explained how when they found their most effective way to travel to university or to work the commute became habitual. This meant participants knew what time they had to leave the house or be on a bus stop. This habitual behaviour proved to be beneficial for participants as they kept using the same transport mode because they did not feel the need to change it as long as their travel needs were being met.

"I don't even think about it [how to commute] I'm in the car and I'm gone…but the journey I have to take if I leave at 6 past 8, I'm going to be fine if I leave 7 mins past 8, I'm going to catch traffic" – Car driver

"I plan my journey a day before… because you never know when construction work is going to happen you never know …even if I know I'm catching the exact same bus I always have to plan a day before to make sure that that bus is coming at this time so I learned my lesson if it says 4 mins delayed, I just leave on time so that I can always catch it if its parking there or even if it's about to depart" – Public transport user

In terms of ridesharing, participants (n=7) recalled how they chose to rideshare with their university cohort or housemates because they wanted to split the driving costs and because they were travelling to the same destination. Out of the seven participants who rideshared three participants already had their car available. From the remaining four participants, after graduating, three moved on to get a driving licence and have their own car while only one was the exception. Participants explained how ridesharing was not something that they did when they started working and only two participants said they rideshared for work and leisure purposes. One participant mentioned how ridesharing as a student with friends is the norm.

"I got lifts with friends a lot when I was younger... I was 22 years old when I got my licence so for five years effectively, I've been getting lifts with friends…and in the beginning that was fine because everybody does that for the first one or two years"

Summary for the capability component

Overall, the capability dimension brought forward the importance of knowledge and skills in navigating transport modes especially public transport and mobility services such as Uber. The lack of confidence in using public transport modes were found to inhibit participants from choosing to use public transport. Thus, both positive and negative experiences of using public transport modes at university were found to be influential for participants future travel choices. Nevertheless, the opportunities available to use certain transport modes also explain graduate employees travel choices.

Opportunity dimension

The opportunity dimension refers to the physical and social opportunity to perform the behaviour.

Physical opportunity

Physical opportunity is “opportunity afforded by the environment involving time, resources, locations, cues, physical affordance” (Michie et al., 2014, p.63).

Environmental context and resources

Environmental context and resources is “any circumstance of a person’s situation or environment that discourages or encourages the development of skills and abilities, independence, social competence and adaptive behaviour” (Michie et al., 2014, p.90). In relation to travel choices, participants were asked about the influence of their available mobility resources and built environment on their travel choice. Participants mentioned several physical and resource factors that facilitated or hampered their travel choices. Many of the subthemes revolved around the level of service where public transport was not considered to be serving their travel needs. Such factors were waiting times, delays, and cancellations, not having a direct route, and not having the correct real time updates on their mobile application.

With regards to the built environment, participants argued how distance dictated what type of transport mode they would choose. Participants (n=13) who lived close to university chose to walk. They would then occasionally use public transport or their personal car if they needed to travel further away. Consequently, the distance to a nearby bus stop or train station influenced participants (n=13) use of such services. Some participants (n=9) remarked how commute distance to a workplace either by public transport or by driving was something they thought of when applying for jobs. Two participants remarked how their experience of a long commute from past jobs led them to search for jobs which had a shorter commute.

"my previous job did teach me that I don’t want a long commute…what I used to do was get a bus and then a train and it would just take forever and I finish at half five, so getting home in the night and leaving about seven in the morning it was too much"

The lack of public transport services located close to a workplace or university campus made participants (n=4) choose to drive because they did not have any other option. Some of the locations of these workplaces and universities would be located in rural areas and sub-urban areas. Hence, the neighbourhood and built environment of the participants workplace and university campus was found to have played an important role in their travel choices.

Another mobility resource is the availability of a smartphone travel app which shows live travel updates of public transport services. Participants (n=9) mentioned how mobile apps which become malfunctioned by not displaying correct travel times would put them off using public transport. Such inaccuracies would cause participants to miss transport services and disrupt their journey to university. Thus, the unreliability of services was found to have impacted participants choice of transport as they transitioned into the workforce. In addition, some participants (n=8) chose not to use the bus because of the lack of direct public transport routes. Moreover, switching between transport modes was considered to be inconvenient and expensive by participants (n=7).

"I might get the train somewhere but I'm still probably going to have to Uber to the exact location on the other side or to get home again so then that's another additional cost"

Resources that impacted participants travel choice were finances and the possession of a driving licence. Finance was the most influential factor for over half of the participants (n=18) when deciding which transport mode to use. Some participants (n=13) explained how using public transport was expensive for them when they were students as well as graduate employees. Hence, most of the participants chose to relocate close to campus and walk to university to avoid having to pay for public transport. When participants graduated, got their driving licence, and bought a car they still considered public transport as expensive because of the first and last mile problem. However, when participants (n=11) needed to travel into the city centre they would choose public transport because parking in the city centre was difficult and expensive. As students, some participants said they managed to overcome the parking issue by ridesharing with friends to split the costs.

"[Ridesharing is] much easier to split the parking fee and … Birmingham it's really expensive parking everywhere so instead of like 4 of us having to pay £8/9 for a few hours we would just split the cost"

Participants who had a driving licence and owned a car during their university phase (n=9) said they would use the car to drive to campus or off-campus lectures, attend work placements and carry instruments. The possession of a driving licence was important when participants started looking for jobs. For some participants (n=9) not having a driving licence meant they were restricted in where to look for work. When looking for a job the priority was to look for workplaces with good transport networks.

"I don't have a car so anywhere that I can't walk to I need to get public transport [otherwise] I wouldn't be able to take the job"

Most importantly, as pointed out by one of the participants, good transport networks are only useful if they serve the participants travel needs. One participant explained how even though they lived close to a busy train station they would not use it because it did not go in the direction the participant needed to get to university.

Social opportunity

Social opportunity is "opportunity afforded by interpersonal influences, social cues and cultural norms that influence the way that we think about things, e.g., the words and concepts that make up our language"' (Michie et al., 2014, p.63).

Social influences

Social influences are "those interpersonal processes that can cause individuals to change their thoughts, feelings, or behaviours" (Michie et al., 2014, p.90). In relation to travel choices, participants were questioned about their interpersonal relationships that could have influenced their thoughts, feelings, or behaviours towards certain transport modes. The extent to which friends and families influenced participants use of public transport and shared mobility services (carsharing, ridesharing, bike sharing or e-scooters) was mixed. Participants (n=5) explained how they would be hesitant to use e-scooters or bicycles because of what others might think of them. Some participants said they would get teased or embarrass themselves. When participants were asked about how their friends and family perceived the use of these services, six participants replied negatively. Their friends and family would question the participants motives for using such transport modes when they could have their own car.

"my family's reaction if I was using the ridesharing service they'd be like, but why don't you have your own car?"

Some participants (n=10) said the negative feedback would stem from the issue of safety. Family and friends would comment on how safe it was to share a ride with a stranger or to use the bus or the train. Nevertheless, participants who rideshared (n=8) were found to have been influenced by the availability of friends who could drive and work colleagues who offered them a lift.

Seven participants remarked how having family members available to drive them to places made them less willing to use public transport. One participant reflected on the fact they always had someone to drive them to university and how they never had any experience using public transport. In terms of whether family and friends influenced participants to get a driving licence four participants said family members had encouraged them to get their driving licence. However, the participants acknowledged how their parents helped them financially to learn to drive and have their own car. Participants' motivation to drive stemmed from the belief that it was essential to have a driving licence when applying for work. Alternatively, two participants said they got their driving licence because they anticipated they would need it when applying for work. One participant commented how now that a few years had passed, they are not sure if they would have got their driving licence if they had not been influenced.

"I think I was influenced I was told that like people look at your CV and they wouldn't consider you if you don't have a driving licence because they think you'll be unreliable and things like that now I know aren't true but at the time it's a step I had to take ok you are kind of finishing uni you are becoming an adult now you get your car and your driver's licence. If I hadn't been influenced at all I'm not certain I would've gotten a car and a driving licence"

Summary for the opportunity component

Overall, the opportunity dimension, shows how environmental context and resources such as commute distance, possession of a driving licence, location of the university and workplace, lack of parking spaces, expensive parking fees and the availability, convenience and cost of public transport services influenced participants' travel choices. In terms of social influence, participants were found to be influenced by their family and friends' thoughts on using services such as carsharing and ridesharing. They were also influenced by their family's availability to take them anywhere and therefore never needing to use public transport. For some participants getting a driving licence was partially influenced by their parents' willingness for them to get their driving licence. Others believed getting a driving licence would be a prerequisite when applying for jobs. Ultimately, participants use of shared services such as ridesharing was a result of the support from their friends and work colleagues who organised such trips.

Motivation dimension

The motivation dimension refers to the reflective and automatic motivations to perform the behaviour.

Reflective motivation

Reflective motivation is "reflective processes involving plans (self-conscious intentions) and evaluations (beliefs about what is good and bad)" (Michie et al., 2014, p.63).

Social/Professional role and identity

Social/professional role and identity is "a coherent set of behaviours and displays personal qualities of an individual in a social or work setting" (Michie et al., 2014, p.89). Participants were questioned on how their social/professional role and identity had influenced their travel choices.

Identities such as being a parent, being female, environmentally conscious or a professional in the educational sector, were found to influence participants' travel choices. Three participants and one other participant who lived in a household with young children, explained how travelling with young children on public transport was difficult. One participant who had a driving licence but not a car opted to use taxis to take their children places or to school. However, the expense of paying for taxis led them to buy a car and be less dependent on other people. The reasons parents and guardians gave for choosing to travel in a car over public transport was because they wanted to travel in a safe environment with their children.

"the more children that I had the harder it became to either relying on other people or catch the bus to be honest I never caught the bus, I caught taxis which is obviously very expensive so getting them to school and nurseries"

In terms of gender, two female participants explained how they felt uncomfortable using public transport and ridesharing services such as Uber or taxis. Hence, one participant chose to walk, and another chose to drive to work. An identity which two participants explained was the reason for them not to have a car or a driving licence was being environmentally conscious. Another identity found to influence participants travel choice was their professional status in the educational sector (n=3). Participants explained how they try and incorporate sustainable practices in their teaching. However, participants in the educational sector need to also set an example for the children in their class.

"the kids [were asking] "miss why are you driving to work?" and then I sit there and think I'm a teacher, I'm going to be a teacher and I'm not really setting a good example for these kids"

Factors related to the professional identity of participants would also include the nature of a participant's job. This means the location of the workplace, needing to travel to different site locations and needing to carry instruments. Such factors were found to constrain participants choice of travel mode. Three participants whose place of work was located in the countryside said they could not use public transport because such services were non-existent at their workplace. In addition, having different working schedules made it difficult for participants to rideshare with housemates or work colleagues. Another participant mentioned how as a musician carrying instruments on public transport was impossible and not driving would negatively affect their work prospects.

Some participants (n=10) got to experience the nature of their future job through work placements as part of their university studies. Seven participants used public transport or rideshared while three participants had a car to drive to their placements. Following their placements, the seven participants who did not have a driving licence, all of them except for one, went on to get a driving licence and buy a car, citing their experience of using public transport during their placement incited their decision to learn to drive. A reason public transportation did not work for participants on work placements was the mismatch between working schedules and public transport service times. Nevertheless, participants (n=7) believe more needs to be done at the workplace to help employees choose sustainable commute modes from the available travel to work schemes.

"there's a lot of home visits and I think during my placement I just experienced how I waste a lot of time to get on public transport. Say I can only visit two families a day with public transport, one in the morning and one afternoon that's it even though it's just a 1 hr [appointment] but it took me 2 hrs to get there and come back so [I would] just save more time if I could drive"

Compared to being employed, some participants (n=13) remarked how as students they had more opportunity to choose public transport and shared mobility services. As students they were offered services at a discounted rate and living with housemates who had cars made it easier to rideshare. Also, start times at university were never an issue unless someone had to commute a long distance and would need to plan ahead to be on time.

Beliefs about capabilities

Beliefs about capabilities is "acceptance of the truth, reality, or validity about an ability, talent, or facility that a person can put to constructive use" (Michie et al., 2014, p. 89). Participants were questioned on how easy or difficult they found using public transport and shared mobility services including the use of their personal vehicle and how this had influenced their travel choices.

Participants (n=11) found ridesharing to be difficult when they started their graduate jobs. Not having anyone to rideshare with and being hesitant to rideshare with strangers, made it difficult for them. It was easier for participants to rideshare when they were students because they had friends and housemates who would be available to offer them a lift. Ridesharing was something participants did occasionally and when available, therefore they mostly relied on using public transport.

Some participants (n=9) said they chose to use the train or the bus depending on how convenient and easy it was for them. Participants (n=18) remarked how difficult it was to use public transport because of its cost and service schedule. Time and cost were two factors which participants repeatedly mentioned when explaining why they would use one transport mode over another or none at all.

"I didn't like it I hated it [public transport]. It was always busy and it was always a bit of a stressful time trying to make sure I could get …to my lectures on time …and it was expensive as well I had to buy a term pass thing and I think that was like 200 pounds for a term…it was just expensive I didn't really like it"

Participants found journeys with no direct public transport routes to be time consuming and costly especially when a change of transport mode would be required. Nevertheless, even though some participants shifted from using public transport when they were at university to driving when they started their jobs, some participants (n=9) continued to use public transport to travel to the city centre. Using public transport to travel into the city centre was found to be quicker, cheaper, and less of a hassle than taking the car. In addition, the experience participants (n=9) had with using public transport as students said it made it easier for them to continue using public transport either for work or for leisure purposes, even after they left university. They attribute their experience during university made it easier for them to navigate different public transport services to know which serves them best.

One factor which two participants found to had influenced their travel choices was the method of payment. One participant said how easy it was to use Uber because payment is done through a smartphone while another participant found using public transport difficult because they could not pay with their bank card.

"I just think it's [Uber] convenient the fact that you can order it on your phone, pay on your phone and it's all automatic I think a lot of conventional taxis expect you to have cash which I never do"

Beliefs about consequences

Beliefs about consequences is "acceptance of the truth, reality, or validity about outcomes of a behaviour in a given situation" (Michie et al., 2014, p.89). Participants were asked how their experience and perception of using certain transport modes informed their travel choices.

Most of the participants experienced public transport and shared mobility services when they were university students. Participants who drove to university said they did experience public transport and shared mobility services occasionally. With experience, three participants found the bus to be more reliable than the train whereas five participants said the train was more reliable than the bus. However, using public transport meant participants needed to be more cautious in case of delays and cancellations. Hence, one participant explained how they felt more in control of timing when driving rather than when taking public transport. This was argued by another participant who said that it didn't matter if they drove or used public transport to commute to work in the city because buses were still prone to road traffic. Thus, the same participant believed the best way to avoid delays was by cycling.

"I would spend an hour in the car when I could cycle maybe 25 minutes in… [What about using public transport?] I think in the city centre the buses tend to get quite bogged down in traffic and then you can be 20 minutes away from work but you're still stuck on the bus for 40 minutes so yeah I could cut my commute down and I would like to do that but I think cycling was the only option that I could realistically do every day"

Participants (n=9) who drove to work said they perceived using public transport with arriving late because of services not being on time. Hence, some of the participants (n=7) recounted how they had to wake up early and get back home late in the evening because of the public transport schedule. When participants transitioned into their employment and shifted to using their private car, they found how little preparation was involved when driving compared to taking public transport. Hence, some participants would not choose to use public transport to commute to work. With regards to ridesharing a few participants (n=6) perceived how if they had to rideshare, their freedom would be restricted. This meant participants would not be able to make detours when travelling to work and back home. With regards to ridesharing as a student, one participant said the different timetables meant one would need to have to wait for the others to finish lectures before anyone could go home.

"I often found it quite easy to take a lift with [friend] because she was quite punctual …our timetables…lined up…however…because I liked to have my own routine or do what I want and having to be ready when they were ready to go home I used to find that quite frustrating they would text me and give me about 10minutes notice like I'm ready to go now and I'd be sitting there well I'm not ready to get out, but I had no choice. I passed my driving test 3 months later"

Intentions

Intentions are "a conscious decision to perform a behaviour or a resolve to act in a certain way" (Michie et al., 2014, p.89). In relation to travel choices, intentions relate to the conscious decision of using certain transport modes for specific purposes.

A few participants (n=6) mentioned how they had decided to exclusively use public transport or shared mobility services for nights out or to visit the city centre. The dense transport network available in the city centre and across Birmingham was found to have played an important role in participants' travel choices. Hence, car drivers chose to travel by public transport when going into the city centre to avoid the parking fees and congested roads. Participants were found to intend to use public transport for commuting purposes only when they could get to work faster and inexpensively provided that public transport services were available at their destination.

"I think a lot of people at work found it really weird that I could drive but I didn't drive to work because they all did but it just didn't make sense for me. So, I'd be paying for more petrol I would be in more traffic I'd have to park 15 minutes' walk away and then walk, whereas if I get the bus it would take me to right outside work"

Participants (n=20) who had a driving licence were asked whether they intended to get a driving licence and what triggered their intention. The majority cited work purposes because of the location or nature of their work. For other participants, ridesharing led them to get a driving licence to avoid relying on other people. Despite most participants holding a driving licence and therefore are not restricted to how far they can travel and what transport mode they can use, transport was found to be important for them when deciding where to work. Granted having a driving licence gave them the freedom to look for work over a wider area, some participants (n=12) said they took the decision to relocate close to a public transport service or to their place of work to avoid having a long commute or drive to work. Participants who did not have a driving licence (n=7) said transport was important for them. They explained how if their potential workplace was not well connected to public transport, they could not take the job. However, if their next job offer was an excellent opportunity which they could not refuse but the workplace was not well connected to public transport, they would not have a problem with learning to drive to get the job they want.

"I think if I found, I had a job and I really wanted it but it was just too far away I could do it [learn to drive] out of necessity, where something is inaccessible and the only reason it's inaccessible is because I can't drive yeah then I would [learn to drive]"

Automatic motivation

Automatic motivation is "automatic processes involving emotional reactions, desires (wants and needs), impulses, inhibitions, drive states and reflex responses" (Michie et al., 2014, p.63).

Reinforcement

Reinforcement is "Increasing the probability of a response by arranging a dependent relationship, or contingency, between the response and a given stimulus" (Michie et al., 2014, p.89). Participants were asked if their travel choices were influenced by incentives or disincentives.

One form of incentive is related to participants well-being. Participants who walked to university or work (n=5) said they chose to walk because they could benefit from doing some exercise and to mentally relax. Other types of reinforcement included financial incentives in the form of discounted public transport passes and disincentives such as parking fees as key factors for participants to use public transport (n=5) or to rideshare (n=7). Another positive factor when using public transport was using commute time more efficiently. Three participants who had a car but used public transport mentioned how they made better use of their commute time when travelling on the train or the bus. This gave them the possibility to work or read a book which they otherwise could not do if they had to drive.

“on the train I'm quite happy. I usually get a seat it's relatively quiet. I chose this mode of transport as well because I can do other things rather than just, I don’t need to concentrate on anything, I like to read so I usually read or listen to a podcast on a train which I wouldn’t be able to do if I did drive”

Emotion

Emotion is “a complex reaction pattern, involving experiential, behavioural and physiological elements, by which the individual attempts to deal with a personally significant matter or event” (Michie et al., 2014, p.90). This refers to participants feelings and emotions as a result of past experiences when using certain transport modes.

When describing their travel behaviour participants used emotional cues to describe how they felt about using public transport and shared mobility services. More than half of the participants mentioned how they felt unsafe because they felt they were being exposed to a danger or risk (n=19). Some participants (n=6) said they were frustrated with the services being unreliable. Others (n=12) rated their use of public transport and shared mobility services on how pleasant or stressful the experience was. Participants explained how using public transport was stressful because they would not know how to use it or because the service was cancelled or delayed and had to figure out how to get to their destination on time.

"with buses its waiting for the bus time sometimes you miss the bus which can be frustrating especially missing a bus and then having to wait or if there's delays as well so that can be stressful"

For participants (n=5) who had a driving licence, using public transport and shared mobility services meant they had to adhere to a strict schedule. These feelings were found to have influenced participants’ travel choices including future choices as they left university and transitioned to the workforce. Eight participants who said their experience navigating public transport was stressful during university chose to drive to work. Of the six participants who found public transport frustrating, five chose to drive to work. Of the five participants who found public transport restricts the freedom to travel any time, four chose to drive to work. Thus, these negative experiences shifted participants from using public transport to driving their own car.

Summary for the motivation component

Overall, participants experiences and personal identities were found to motivate them in their mobility choices. Positive and negative experiences were found to influence future choices. Knowledge of using public transport enables participants to better access public transport and to use it when visiting the city centre. However, using public transport is considered to be a stressful experience when going to work and therefore this leads participants to choose their more reliable car for such journeys.

6.2.4 Participants' reception to MaaS

Participants were introduced to the concept of MaaS and how it could work. The purpose of this exercise was to gather participants openness to using such a service which could potentially shift them away from their private vehicle, or the thought of purchasing one, and towards public and shared transport services. They were informed that MaaS was not yet available commercially and asked if they had heard of the concept before, what they thought of it and whether it would serve their travel needs. Appendix F provides a table with a summary for each participant on what they thought about MaaS fitting their travel needs.

None of the participants had prior knowledge of the service with only one participant having heard of the concept but not in any detail. Participants (n=7) who used to commute by public transport to university compared it to existing smartphone travel apps such as Google Maps and Uber. However, participants recognised the different features MaaS could offer compared to existing travel mobile applications.

"looks like [MaaS] you getting on an Uber or something, but it goes a bit further taking all the modes of transportation into it but then it's a subscription thing rather than a one-off type than an Uber"

Some participants (n=7) perceived their use of MaaS would be easy because of their experience with using smartphone travel apps to book and pay for a travel service or to check live travel times.

"I think it would be really easy it would just be like another app on my phone another subscription service"

In addition, experience of using mobile applications that malfunction or were complicated to use led some participants (n=7) to lose interest and not use the service.

"I do think it's how easy it is to use as well you know... a few of the apps that I've used before I think [in] particular [the] bus app in Birmingham it's just a bit frustrating [that] you eventually stop using it"

Train commuters (n=6) found the use of mobile applications to be convenient for checking live travel times and to pay for their ticket. When their trains were cancelled most of the participants resorted to using other transport modes sometimes booking the service via their smartphone. Thus, participants perceived MaaS could simplify and facilitate their journey when trains are delayed or cancelled. Participants who had experience using different bus companies and train companies said MaaS would be useful if it could integrate all the available services into one digital platform. Overall, the cognitive and interpersonal skills including participants memory of using similar products to MaaS such as Uber or the bus app in Birmingham, indicates participants psychological capability to use MaaS.

Participants who used public transport and drove to work showed interest in the service based on the opportunities available. For instance, those who walked to their workplace (n=4) said MaaS would fit in with their leisure travel needs because they did not have a driving licence and tended to use public transport or taxi services. Participants who used public transport for work believed MaaS could serve both their commute and leisure travel needs. However, one participant who used the train to commute to work, said they did not see MaaS as serving their needs. Having found the best way to commute, the participant said they would not want to change it.

"I so rarely need to change the way that I commute or want to change the way that I commute because I've found the best options for me"

Whether MaaS could serve the travel needs of car owners, participants had mixed reactions. Only four participants said they would stick to using their car and would not be interested in a MaaS subscription for any travel purposes. These same participants remarked how their dependency on the car was a result of them having adapted to using their car for all their travel purposes. Moreover, the same participants said the fact they needed to commute to different places for work or to areas where public transport services were not available, it would be difficult for them not to use their car. On the contrary, car owners (n=7) who said they would use MaaS for work purposes were found to already be public transport users.

"I think not [MaaS fits commute travel needs] just because [the workplace] is out of the way. The quickest bus route for me to get there would just be on the back roads that would take me 3 times as long to do because it would go through towns"

Nevertheless, car owners who said they would use MaaS for their leisure purposes (n=7) and not for commuting purposes cited the flexibility of having a car compared to using public transport for work.

"[MaaS] it sounds amazing I'd love to use it but I'm not sure it would kind of work for me right now especially with work because I kind of I have to be there at a certain time so I can get all my jobs done before the students come in and then you know I don't always leave at the same time every day some days I stay later sometimes I get all my stuff done and I can leave earlier so yeah I think having that flexibility might not always work with that [MaaS]"

Participants mentioned how they would use taxis or public transport when going for a night out, choosing not to drive because of potential drink-driving penalties. Therefore, MaaS could be beneficial to use when going out for social activities.

"if I'm going out in the evening I'm not driving anyway because I might drink so I would actually consider it [MaaS]"

Nevertheless, one participant said their likelihood of using MaaS would depend on the availability of carshare services. Each participant mentioned how they had their own preferences for which transport modes to use for different travel purposes. Nine participants mentioned it would be useful to have Uber included within the subscription citing the problem of public transport services not being available after hours. Participants (n=8) said they would be motivated to use MaaS if the service offered flexible subscription plans for regular and non-regular public transport users. Moreover, they would find value if MaaS offered them a personalised travel plan, including all their travel needs, for an affordable price. This means MaaS would need to create an opportunity for participants to use it by providing a range of services and a range of subscriptions that fit participants financial budget with the aim to reduce private car use.

"[if] you could have a plan that is a combination of Uber and bus that would be ideal for me because that's basically what I use in normal life I very rarely use my car I only really use it for food shopping so I can carry lots of stuff or for long distance journeys where I've got luggage…ordinarily I would get the bus to work and I would get Uber into the city centre to do anything social like for a day or night out …that's what I would normally do"

More than half of the participants (n=16) said the cost of the subscription would determine whether to subscribe or not. Car owners who used public transport to travel to their place of work (n=4) said they would find MaaS useful because they rarely used their car except when the journey by public transport would be complicated with too many transfers. However, for them to choose MaaS, it would need to offer a competitive price compared to the available transport subscriptions and the use of their private car.

"I think cost would be an important thing because if you don't earn a lot of money then you know commute is already a large cost so you wouldn't really want to be spending more than you currently do on it just for the convenience of having the app"

6.2.5 The impact of the Clean Air Zone and Traffic Cells Initiative on participants' travel behaviour

After asking participants on their perception of MaaS and whether it fits their travel needs, participants were asked if they were aware of the implementation of the CAZ from June 2021 onwards. Appendix G provides a table with a summary for each participant on what they thought about the CAZ.

Most participants showed good knowledge of the CAZ with many comparing it to London's congestion charge. Thus, participants showed perfect psychological capability of knowing what the CAZ involved and why the charge was being implemented. Participants reaction to the charge was mixed and this was explained by the frequency of trips participants made and for what purposes. Most participants visited the city centre for leisure purposes. Only four participants said they commuted for work in the city centre. Hence, the impact of the CAZ on participants trips into the city centre would have been more pronounced had they been working in the city centre and needed to commute daily. Although the aim of this qualitative study was not to generalize, but to provide a rich contextualised understanding of graduates' travel choices, results would be more robust if more participants who commuted to the city centre were recruited.

From the four participants who worked in the city centre, two used their car, one walked and the other used public transport. The two participants who drove into the city centre said with the CAZ their commute would probably be longer and even though for now their car was exempted, they would need to either change their commute or buy a new car to avoid paying the daily charge. Thus, participants acknowledged the consequences if they wated to continue using their car to drive into the CAZ. Participants who used public transport to commute to work said the CAZ might make public transport services busier than they already were.

"It might affect me because the train might be busier as people are encouraged to commute you would hope that transport services respond to that fairly efficiently"

The cost of the daily charge was found to put off participants from driving into the city centre. Car owners (n=11) who had positive reviews about the CAZ were found to have used public transport when visiting the city centre. Therefore, their experience had provided them with the knowledge and skills to travel by public transport. The remaining car owners (n=6) had negative reviews of the CAZ. These stemmed from participants anticipating parking issues because drivers wanting to visit the city would be parking in the neighbourhoods at the edge of the city centre to avoid the zone charge. Consequently, this would negatively impact the residents in the area. In addition, the CAZ would constrain participants when they could visit the city centre. To justify paying the zone charge participants said they would visit the city centre on the occasions they would need to shop. Otherwise, they would prefer to visit other places to avoid paying the zone charge. Nevertheless, one participant remarked how the CAZ might not put them off driving because the cost of the charge zone and the parking fee could be less than the train ticket. Therefore, it would be cheaper to drive into the city centre and pay the charge. Overall, participants believe the impact the CAZ would have on Birmingham would be positive even if it limits their car use.

"I fully support this because I think Birmingham as a city has been completely destroyed by the car big time"

Compared to the CAZ, a Traffic Cells Initiative was also being implemented. On the contrary to the CAZ, participants did not show any knowledge of the Traffic Cells Initiative map. The latter was found to demotivate car drivers who had previously accepted to pay the zone charge. The reason was that the Traffic Cells Initiative would complicate their journey as the restrictions would make the ring road busier and driving in the city centre would be impossible. At the time of the interviews a few traffic measures were already being implemented and one participant mentioned how driving in the city centre had become difficult with long travel times, prompting a change in transport mode.

"it's (Traffic Cells Initiative] already having an effect on me and how I get where I need to practice so yeah, I'm already considering cycling or walking"

Nevertheless, all participants had positive reviews on the CAZ and Traffic Cells Initiative. They understood the need for it and evaluated the financial consequence and the quality of the environment because of the CAZ on the city centre. The negative reinforcements of restricting car access and imposing a daily charge to drive into the city centre were shown to motivate participants to switch towards other transport modes. However, to be able to switch, the opportunity needs to be available in the form of better quality and reliable transport networks.

6.2.6 The role of MaaS considering the Clean Air Zone and Traffic Cells Initiative for study participants

Travel restrictions are expected to discourage drivers from using their personal vehicle and to opt for alternative modes of transport. Therefore, participants were asked if MaaS could potentially serve their travel needs when visiting the city centre, considering the CAZ and Traffic Cells Initiative. Appendix H provides a table with a summary for each participant on what they thought about the potential for MaaS considering the CAZ and Traffic Cells Initiative.

The consensus was MaaS would be useful given the restrictions on car use and driving within the city centre. Reasons and suggestions varied. Six participants believed MaaS would make it easier for the user by suggesting alternative ways to travel when one transport mode is found to be busier than the others. Moreover, participants (n=6) perceived MaaS would make it easier for travellers outside of Birmingham visiting the city for work and leisure purposes. Hence, the usefulness of a MaaS app for everyday travel provides travellers with an opportunity and motivation to use the app.

Three participants observed how MaaS included taxi and Uber services and hence in case of any delay, participants could easily order a taxi or Uber. However, with the implementation of the CAZ and Traffic Cells Initiative, they were concerned with the probability that to use such services they would need to pay a higher subscription cost and that their journey might take longer. The cost of the subscription was found to be a critical factor for participants. Three participants said the cost would need to be affordable compared to driving and paying for parking and the zone charge. Another two participants said they would choose MaaS to avoid parking costs and the zone charge. However, one participant said MaaS would need to be cheaper than £8 per day. Alternatively, two participants estimated it would be cheaper to rideshare and split the costs rather than subscribing to MaaS. Thus, the cost of the subscription was found to be an important factor for participants decision to subscribe to MaaS.

"at the end of the day if I calculate how much I'm going to pay for the subscription and I calculate how much is going to get £8 a day into the city that's £40 per week in some places you can get like a block booking for parking so if I calculate all that and I find out its way cheaper for me to get into my car rather [than] using MaaS then I will get into the car"

6.3 Discussion

This study applied the components of the COM-B model and TDF domains to help understand the influences on participants' travel choices as they transitioned from university education to the workforce. Universities frequently promote the improvement of sustainable mobility within their premises (Pérez-Neira et al., 2020). However, participants in this study seldomly could remember any sustainable transport campaigns and sustainable practices at their university or workplace. Participants recounted how commuting outside campus for work placements or lectures required them to choose a suitable travel mode sometimes different to the one used to commute to campus. Having reached the age to get a driving licence many participants said they got their driving licence when they were at university but chose to delay their car purchase until they were financially more stable. Participants showed how their experience at university gave them the knowledge and skills to choose their mode of travel. Nevertheless, participants acknowledged the need for more education and training on how to travel sustainably. The hidden costs of owning a car need to be communicated more and compared to using public transport to encourage a shift away from the private car and towards public transport.

As participants transitioned from university education to the workforce, a few changed their choice of transport mode. The reasons for such changes included experiences, intrinsic motivations in terms of finance and well-being and opportunities facilitating the availability of public transport. These three factors were also found in a study by Chatterjee et al. (2013) which explained changes in travel behaviour following a contextual change. Similarly, Kurniawan et al. (2018) observed how life stage needs and the purpose of travel influenced mode choice. Hence, some of the participants in this study explained how their work placement experience motivated them and made them think of the consequences if they had to choose one transport mode over another. These results were found in a study by Busch-Geertsema and Lanzendorf (2017) where for instance dress-code requirements led to participants changing mobility as they transitioned from university education to the workforce and in a study by Clark et al. (2016) claiming poor accessibility to employment by public transport leads to the purchase of a first car.

The implementation of the CAZ and Traffic Cells Initiative made participants think about their travelling into the city centre. The restrictions of driving from one area to another and the need to have a car that meets the emissions standards, motivated participants to think of alternative travel modes. Participants reaction towards the CAZ and Traffic Cells Initiative was strongly influenced by their trip purposes into the city centre. Participants who worked in the city centre and used their car, said they would need to find alternative ways. On the other hand, participants using public transport said they might encounter busier services if everyone was encouraged to use public transport. The impact of the CAZ and Traffic Cells Initiative on participants travelling into the city centre for leisure purposes was found to be minimal. Participants making leisure trips thought about the impact on taxis and Ubers possibly increasing their prices and making the journey longer. Nevertheless, most car drivers said they already used public transport instead of their personal car when visiting the city centre to avoid parking fees and road traffic.

During the interviews, participants interest in MaaS increased following the awareness and knowledge of the restriction measures to be implemented in the city centre. The concept of MaaS was received positively and participants found it to provide them with the opportunity to travel into the city centre and avoid parking fees, zone charges and road traffic. Their perceived capability to navigate public transport using MaaS was a result of their experience using other subscription services. Thus, the potential introduction of MaaS as a soft measure in parallel to the hard measure of car restrictions implemented in the city centre would be beneficial. The deployment of soft measures with hard measures is considered as motivational support for individuals to change commute mode (Gärling and Schuitema, 2007, Guzman et al., 2020). Thus, MaaS has the potential to encourage car owners to visit the city centre by public transport instead of their personal vehicle.

The TDF domains were ranked according to the frequency counts of the elicited sub-themes shown in Appendix E. The top three domains influencing participants' travel choices were environmental context and resources, social influences and professional identity, and beliefs about their capabilities. When grouped together, five themes emerge as the most important factors that influenced participants' travel choices as they transitioned from university education to the workforce. Each of the following themes are discussed in the following sections:

1. Public transport is not suited for certain professional jobs
2. Being on time and commuting a short distance are a priority
3. "It all comes down to the price" – the impact of cost on travel choice
4. Use of shared mobility services is enabled by social networks
5. How much effort does it take?

6.3.1 Public transport is not suited for certain professional jobs

Participants' travel choices were shaped by the opportunities available in terms of the accessibility to public transport at the workplace and the need to carry instruments or visit several clients as part of their job.

Workplaces located in areas which were not well connected to a public transport network led to participants automatic choice of commuting by private car. If participants did not yet own a car their family members would drive them to work. The reliance on other people to drive them motivated participants to get their driving licence and eventually own a car. In addition, the lack of direct public transport routes was found to deter participants from commuting by public transport. In a study by Clark et al. (2016) using a representative sample of the English-working population, workplaces with high quality public transport links to employment centres were found to encourage non-car commuting. Thus, the availability of good transport links provides workers with the opportunity to use public transport. One participant said to have found public transport easier and quicker than driving because their place of work was well served by public transport. Nevertheless, some participants remarked how their jobs required the use of a car and therefore even if the opportunity was available, they would not be motivated to use public transport. This was explained by the need to visit several clients within a day or needing to carry instruments for work.

These results show how the lack of public transport services close to the workplace and the nature of the work dictated what types of transport modes participants could use. The promotion of sustainable transport modes by the workplace needs to be tailored to the specific workplace. Crawford (2020) made references to the different types of working schedules and how conventional interventions were designed on the traditional regular worker. The changing needs of travellers need to be considered to successfully design transport networks and services that serve the needs of the working population. Properly designed transport networks and services would provide participants with the opportunity to commute efficiently and as needed. Participants perceived MaaS would be beneficial as it would give them the opportunity to plan their journey more efficiently using modes suited to their travel needs. However, MaaS plans would need to be flexible to attract different types of travellers (Hoerler et al., 2019).

6.3.2 Being on time and commuting a short distance are a priority

Time and distance constraints were the most reported factors influencing participants choice of transport modes. With regards to time, participants said their need to arrive on time for work meant they would not use public transport because of their past experience with using the service. Their experience with getting to lectures late, having to deal with delays and cancelled services and long waiting times was stressful and frustrating. Therefore, participants beliefs on the negative consequences of using such transport modes influenced their travel choices. Some participants experienced this during their work placements which motivated them to start driving for their full-time graduate job. This is supported by Clark et al. (2016) who argued behaviours learnt in the past may exert a strong influence on how people adapt to new situations following life events.

The expectation of participants to be on time for work made them less confident using public transport services. Citing unreliable public transport services and the public transport schedule not aligning with their working schedule. However, when one participant had to go without their car for weeks, communicating with their manager meant they could have their working schedule shifted to accommodate the public transport schedule. This shows how given the right opportunity such as flexible working hours, employees can be motivated to use alternative methods to the car. In a study by Ben-Elia and Ettema (2011) workers who received support from their employer by arranging flexible working times were less likely to drive during rush hour, showing how flexibility at the workplace can promote changes in travel behaviour. Arranging flexible working times can put less pressure on workers to arrive on time for work and therefore can allow them to use alternative transport modes to the private car.

Participants said the working schedule was inflexible and made it difficult for them to consider ridesharing. As students, participants said they had more opportunity to rideshare with friends and housemates whenever they needed. Citing living with, or in close proximity, to friends who owned a car made it possible for them to rideshare. Having moved away from the university context and not living close to work colleagues, participants found ridesharing difficult. The opportunity to rideshare was not available anymore to participants however the motivation to organise rideshare trips was also not predominant. Employees are known to chain personal trips with work trips (Shin et al., 2020), therefore participants said they would not want to rideshare because it would restrict their freedom from making any detours and it would prolong their commute. The issue of ridesharing at the workplace was reported in a study by Hesselgren et al. (2020) where given the opportunity to rideshare, two thirds of employees that used to commute by car continued to do so because neither public transport nor the ridesharing system set up served the needs of the participants. Hence, the opportunity to organise ridesharing trips needs to be promoted at the workplace with possible incentives to motivate workers. Incentives such as allocating parking spaces and subsidizing petrol costs for rideshare work colleagues would impact workers travel choices.

With regards to the short commute distance, participants said having a short commute would allow them to walk to work or catch public transport. Commuting a short distance was found to be motivated by the benefits of including daily exercise, time for oneself and to use the time for reading or listening to a podcast, without the need to focus on driving. Past experiences of commuting long distances influenced participants future decision to find jobs with a short commute distance. Travelling long distances was considered as a waste of time and financial resources. One participant rationally said it was not financially feasible to commute long distance, unless the employer was paying for the commute. To reduce their commute time, some participants chose or were thinking of relocating closer to their place of work or to a public transport service. This is supported by Clark et al. (2016) who found the wish to reduce commute time led to relocation or a change in employment among their participants. This is explained by the residential self-selection hypothesis which suggests households choose locations based on how they expect or prefer to travel (Jones and Ogilvie, 2012, De Vos et al., 2012, Handy et al., 2005).

Participants can be said to have created their own opportunities to use public transport and have a short commute by relocating close to their workplace or to a public transport network. The reason for wanting to relocate closer to a workplace was similar to how participants chose to relocate close to their university campus. Participants chose to relocate close to their university because they wanted to walk and avoid using public transport. Relocation as a student and as an employee were found to be motivated by both time and distance.

A key feature of MaaS is offering services on-demand. Participants found real time travel updates and suggestions for the most efficient transport journey would be helpful. One of the factors of MaaS is of offering on demand transport modes such as carsharing and taxis which can help customers to use when public transport is delayed or the service is cancelled (Martin et al., 2021). Hence, participants acknowledged how their commute would be less disrupted if MaaS would provide them with the opportunity to use on demand transport services to replace delayed and cancelled services. Nevertheless, the success of MaaS relies on offering fast, accurate and real time support for travellers as transport users become more demanding for faster, more frequent and more transport options when travelling (Araghia et al., 2020).

6.3.3 "It all comes down to the price" – the impact of cost on travel choice

Financial cost was another factor which influenced participants choice of commute. To avoid paying for public transport most of the participants when they were attending university chose to walk to campus or buy a student travel card to take advantage of reduced travel fares. As participants transitioned to the workplace, the issue of finance was still prevalent for some participants. Two participants explained how they chose to walk to their workplace because they were saving up to do a master's degree. Similarly, participants living with their parents said they did not feel the need to relocate because they wanted to save on accommodation costs and because they could travel to their workplace conveniently from where they resided. Moreover, participants were discouraged from using public transport because they needed to use two or more modes because of a lack of direct transport routes. The use of two or more transport modes was considered as too expensive. Therefore, participants' travel choices were shaped by their financial resources which did not provide them with the opportunity to be flexible.

The use of financial reinforcements such as discounted travel tickets were found to be beneficial and allowed participants to travel on a budget. The positive impact discounted travel cards had on graduates transitioning to the workforce was reported in a study by Busch-Geertsema and Lanzendorf (2017). The authors found job starters who still had a student ticket available continued to commute by public transport to work. Similarly, in a study by Thøgersen (2012) an intervention group that received a free one-month public transport travel card and had moved home or changed their workplace, were found to increase their use of public transport. Hence, introducing such a measure by employers to new employees might be beneficial. As argued by Shin et al. (2020) the availability of different types of commuter benefits is associated with workers travel behaviour. Clark et al. (2016) explain how people are more likely to change commuting behaviour when they start working for a new employer and therefore policy measures are likely to be most effective when aimed at new employees.

Nevertheless, participants bought their car when they started their graduate job which provided them with the financial stability to afford the purchase. Being employed gave them the opportunity to buy their car, however their experience of commuting and maintaining a car motivated some participants to look into corporate travel cards. Whillans et al. (2020) explain the sunk cost bias where car owners who had already made an upfront investment to buy their vehicle would feel more committed to drive. In this study, some participants who owned a car did consider the use of public transport as being expensive considering they already had the car available to them. The consideration of car owners to use alternative travel modes stemmed from the costs associated with running a car. Parking fees and petrol costs managed to motivate participants to use public transport when possible. Participants chose to commute by public transport or carshare with friends and colleagues to split the costs. The combination of parking restriction and the use of shared mobility services was reported by Johansson et al. (2019). Johansson et al. (2019) found the availability of car and bike sharing clubs combined with parking restrictions in a newly built-up area with two blocks of apartments in Sweden, decreased car ownership with indications that the use of public transport had increased. Thus, limiting parking spaces and imposing parking fees are policy interventions that place additional financial burdens on car users (Carroll et al., 2017) and therefore can be used to shift drivers away from using their private car.

Car owners needing to travel to the city centre were not motivated to use their car because of the lack of parking spaces and parking fees. Removing the opportunity for car drivers to park and imposing a financial disincentive such as parking fees demotivates car drivers from driving. From the 17 participants whose place of work was in Birmingham only 5 participants said they drove to work. Most participants used public transport or walked to work. The participants who drove to work justified their use of the car with the nature of their work. However, the introduction of a daily CAZ charge had made two of the five participants who drive to work in the city centre to rethink their commute. The CAZ charge and longer commute time due to the Traffic Cells Initiative prompted all participants to evaluate how they travelled to the city centre and for what purposes. Most participants saw the charge as a positive deterrent motivating them to use more sustainable transport modes. One participant mentioned how the charge was a *'necessary evil'* to shift people from driving to using public transport services. The positive reviews may be explained by most participants mainly travelling for leisure purposes. People who commute regularly to the city centre would be expected to have different views. Nevertheless, many participants remarked how the city centre is highly accessible by public transport and that there was no excuse to be driving.

Car drivers perceived MaaS as a potential solution to travel to the city centre to avoid paying the CAZ charge as providing them with an affordable journey using the transport modes they need. As expected, the cost of a MaaS subscription was found to heavily influence participants potential use of the service. The cost would need to be competitive in comparison to other available travel subscription services. Participants who used two or more transport modes explained how for them to buy a day ticket for one transport mode and needing to buy an additional ticket to use a different transport mode within the same journey was too expensive. Hence, the creation of a discount ticket with access to multiple transport modes such as MaaS would make it convenient for travellers needing to switch between transport modes.

6.3.4 Use of shared mobility services is enabled by social networks

Some participants explained their lack of public transport use was because of their lack of public transport experience; whenever these participants needed to travel family members would drive them. The social opportunity participants were given by their family led them to being inexperienced with using public transport modes. Similarly, the social opportunity participants had with ridesharing was provided by their friends and work colleagues with private cars. Therefore, participant's social network shaped their travel choices. The influence that parents, schools, or other key institutions may have on children's travel behaviour was reported by Scheiner and Holz-Rau (2013) to possibly be continued in later life. However, participants continuation of ridesharing after leaving university was not found prevalent and was explained by the different work commitments and the need to relocate in an area different to where their friends were.

The results found no positive incentives or beliefs motivating participants to rideshare for work purposes. On the contrary, participants believed ridesharing would constrain their personal freedom from making detours on their way to work or back home and to prolong their travel time. To promote the use of ridesharing within the workplace, Darnton et al. (2006) suggest using individuals as 'agents for change', using managers and change champions to promote sustainable transport modes. Providing employees with accessible sustainable transport options, a culture that encourages environmentally friendly behaviour and a sustainable travel policy would be beneficial to have within organisations (Andersson et al., 2020). Most participants who said they would consider ridesharing found it difficult because they did not know with whom to rideshare. Acknowledging the technological advancements made in travel apps, having a mobile application which identifies rideshare users was suggested by participants to be helpful. Thus, participants suggested MaaS would be helpful if it could include a feature whereby users could be matched with other rideshare users in their area.

Nevertheless, participants would only consider ridesharing with friends and family, people they know. Participants did not feel comfortable ridesharing with strangers. The issue of safety was always prioritised when choosing which transport mode to use and participants believed friends and family would not approve of them using such services. To circumvent the issue of safety, participants spoke about a safety feature used by Uber. The safety feature made it easier for participants to choose the service as it allowed them to share their location with friends and family so they can be tracked. Moreover, information on the driver and vehicle was also provided to the users. Hence, participants made the recommendation for the MaaS app to have such a safety feature. Such a feature was said to make MaaS more appealing and would motivate participants' use of MaaS.

6.3.5 How much effort does it take?

Participants' choice of transport mode was shaped by their cognitive ability and belief of their capability to use different transport modes. This meant the ease of use of public transport to visit the city centre and the amount of preparation and planning involved when using public transport services shaped participants' travel choices. Participants would use public transport to travel to the city centre because it was easier, quick, and cheap compared to driving which would involve being stuck in traffic, looking for parking and paying for parking and petrol costs. On the contrary, using the private car for work purposes was found to be easier, reliable, and convenient for drivers. Public transport for work purposes was considered as unreliable because of the delays and cancellations, restricted because of its transport schedule and long winded because it needs to travel to other places before getting to the participant's destination. Nevertheless, some participants who drove to work made comments about having to leave home at a certain time to beat the traffic. The difference between using public transport or getting in the car was explained by the convenience of a door-to-door journey when using the personal car.

A participant's choice between one public transport mode over another was motivated by the relative distance to access the service from the participant's home. This was superseded if their workplace was closer to either the bus or the train. The payment method was also found to influence participants' choice of transport mode. Paying by card or using their smartphone made using alternative transport modes to the car much easier for participants. These results show how participants favour transport modes which are effortless. The location of transport services, their ease of use in terms of payment and accessibility and providing a door-to-door service without disruptions motivated participants to use such transport modes. Hence, participants said they travelled by public transport to the city centre because the centre was accessible by dense railway and bus networks going across Birmingham.

Emotional cues related to the use of public transport were found to discourage participants from using such services. Participants who had a stressful experience said they switched to more reliable transport modes such as taxis or started driving. In terms of MaaS, participants likened it to existing travel apps and because their experience with using such apps was mainly positive, albeit a few glitches, participants saw MaaS as an opportunity to provide them with an effortless journey. The effortless journey was explained by the use of multiple transport modes all paid for in advance through a subscription. Therefore, they would only need to input their starting location and destination location and the app would provide them with the most efficient journey in real time. Some participants questioned how efficient MaaS can be considering the service would be promoting the use of existing transport modes such as the bus, train, and Uber. Hence, participants said they would be willing to trial the service before subscribing. This was also found in a study by Alyavina et al. (2020) where participants said trialling the service for free could be beneficial to help increase the adoption of MaaS.

6.3.6 Can MaaS help sustain young adults’ travel behaviour?

This study has shown how MaaS expands the opportunities for participants to travel efficiently using different transport modes through a subscription service. Participants believe the availability of such a system would be sensible with the implementation of the CAZ charge and Traffic Cells Initiative. The driving restrictions and daily charge was found to motivate participants who used their car when visiting the city centre to consider using public transport. One participant said the easiest way for them would be to drive to the train station and catch the train into the city. With the implementation of the CAZ charge and Traffic Cells Initiative participants using public transport anticipated an increase in the demand for the service. Thus, travellers would be looking for alternative transport modes that are less busy. To solve this, MaaS could provide travellers with the opportunity to access a range of transport modes with the possibility of providing real time updates on how busy the services were. This would allow the user to make a choice based on the information provided by MaaS.

The perceived ease of use of MaaS was found among participants who had the cognitive ability to navigate smartphone travel apps. Such participants likened MaaS to existing smartphone travel apps and therefore provided more insights into which features would make MaaS valuable. For example, participants suggested MaaS would be more appealing if it had the same safety feature found in the Uber app. Similarly, participants who made use of discounted travel fares as students remarked how MaaS would need to compete with other existing travel subscriptions. Nevertheless, participants suggested the need for flexible subscription plans to cater for regular and less regular public transport users such as a pay-as-you-go option. With regards to the subscription, participants emphasised the need for this to be flexible enough for participants to choose their preferred transport mode instead of being given predefined subscription plans.

The need for flexibility stemmed from participants beliefs for which travel purposes MaaS would be considered suitable to use. Participants associated the use of MaaS with public transport and taxi services. Therefore, most participants used such transport modes when travelling to the city centre for leisure purposes and when going out socially in the evening. The location of their leisure purposes and personal intention not to drive when going out socially were found to encourage the potential use for MaaS among participants.

In terms of using MaaS for work purposes, participants believed their private car was more suited to their travel needs for work. Some participants cited the lack of public transport networks close to their workplace, needing to travel to different clients during the day and the need to carry instruments for work discouraged participants from using public transport and hence finding MaaS useful. The possibility of ridesharing was turned down by participants citing not knowing who to rideshare with, restricting their freedom from making detours and adding to their journey time discouraged them from organising or partaking in any rideshare trips.

Whether MaaS can help university students transition into the workforce and choose sustainable transport modes would be dependent on their experience using the service during their time at university. MaaS would need to be promoted during this window of opportunity to reduce the possibility of young adults becoming captive drivers as they transition into the workforce. Moreover, the inclusion of financial incentives and trialling the service for free were found to increase participants' motivation and interest to use MaaS. Busch-Geertsema and Lanzendorf (2017) suggest such campaigns to be held at universities particularly for final year students in order to reach the job starters before important decisions and acquisitions regarding travel modes have been made. However, similar campaigns should also be available in colleges as some participants were found to have started driving before starting university.

6.3.7 The impact of the pandemic on participants' travel choices

The pandemic with all its travel restrictions had a huge influence on participants' travel choices. From the 27 participants, 11 participants continued to commute to work while the remaining worked from home. Seven participants used to drive to work before the pandemic and continued to do so. Two participants continued to commute to work on foot and one other participant used the train to get to work. Only one participant was found to have changed their travel commute mode due to the pandemic. Prior to the pandemic the participant used to use the bus to travel to work, since the pandemic they started using their car to travel to work. This shift was motivated by the availability of parking spaces on the company's premises and the less congested roads. In fact, many participants who drove to work said the pandemic had significantly reduced their commute time. This made it easy for participants to commute by private car knowing they could get to work in a short time without any traffic. This was a result of the government-imposed restrictions on travel advising people to work from home and travel only for essential trips. Hence, one participant said how the pandemic had impacted their usual travel to the city centre:

"Although I say that whenever I travel into Birmingham city centre before I used to take public transport, I would never drive, I had a reason to go in last week and I drove because it took me 29 minutes to get to the very centre of Birmingham from my house and the train takes 30 mins and I have to get to the train station so COVID has made me want to drive more"

Participants (n=13) said the pandemic had made driving a more pleasurable experience further reducing any intention for them to use public transport. This motivation stemmed not only from having fewer cars on the road but also because of safety. The UK Government was advising people to avoid public transport to reduce the spread of COVID-19. Public transport was labelled as risky because the person inside a vehicle was expected to stay in a limited space with no social distancing and with common surfaces being touched (Dingil and Esztergár-Kiss, 2021, Degli Esposti et al., 2021). Participants were being provided with knowledge on how using public transport was a risk. Therefore, the motivation by participants to travel safely led to changes in participants' travel choices. Participants who had a driving licence and owned a car chose to use their private car over public transport. However, participants who did not have the skills to drive or financial resources to own a car, were left with no choice but to use public transport.

The COVID-19 pandemic has given safety another meaning and participants' motivation for particular travel choices have sharply changed. Pre-COVID, participants (n=19) referred to being concerned about their safety in terms of travelling with people they did not know and being robbed or harassed on public transport. While the same safety issues continued to apply, with COVID-19, participants (n=7) spoke about their safety in terms of having enough space to socially distance from other people and their risk of getting ill from staying in a confined space such as a bus. Degli Esposti et al. (2021) and Anke et al. (2021) found safety concerns in their studies caused people to be less likely to use public transport and carsharing.

Participants' travel choices were more sensitive to how safe it was to travel using one type of transport mode over another. During the pandemic, two participants said they had to use public transport for the odd occasion when they had to travel to the office. Their experience of using public transport during the pandemic was described as pleasant because they could get a seat and the service was less busy so they could easily socially distance from other passengers. Even though participants acknowledged the less frequent services they said they understood the situation.

The impact of COVID-19 on travel choices is still evolving at the time of writing this thesis. The variability of the situation poses a challenge for researchers to study the adaptations of travel behaviour and mode use by different user groups as the expectations of people to commute to work, go out for leisure activities or escort children to school changes. Hence, further studies would be published evaluating the potential of the behavioural and policy adaptations implemented by the pandemic. In the study context of Birmingham, the Birmingham Transport Plan which was planned for adoption in autumn of 2021 had changed to an Emergency Plan in 2020 implementing measures to support walking, cycling and public transport throughout the city, measures which had already been presented in the Birmingham Transport Plan. This was also revealed in a study by Marsden and Docherty (2021) who explored the extent to which rapid policy change had been possible in the transport sector in England and Scotland during the pandemic. The authors found the pandemic had accelerated some policy commitments that were already planned.

With reference to the potential adoption of MaaS, one participant remarked how the pandemic could have impacted the potential acceleration of MaaS adoption. The pandemic has encouraged users and operators of public transport and taxi services to avoid cash payments from clients. The spread of the virus was reported to be through contaminated surfaces and therefore cash payments were considered as a risk for spreading the disease. Therefore, the public were encouraged to use digital tickets by purchasing them online and people using taxi services were encouraged to pay online using their bank card or by contactless payment. One participant highlighted how the drive to educate and encourage people to download public transport tickets and book and pay for taxi services through a smartphone app could catapult the diffusion of MaaS when the service becomes available.

6.4 Limitations and further research

The present work supplements the existing body of literature to identify the factors influencing graduate employees' travel choices and the capability to qualitatively understand their impacts. However, this did not happen without limitations. A convenience sample was used to recruit participants who were compensated for their time. Thus, participants who showed interest in taking part could have been motivated by personal interest. Hence, such participants could have different personal characteristics to the general population. Another limitation was the sample size. The results were collected using a small qualitative sample of 27 people. Although data saturation was reached, the results would be more robust with a larger sample. A further limitation was the participant criteria. Despite succeeding in recruiting participants who had graduated within the last 3 years and lived and worked in the West Midlands, only four participants travelled into the city centre for work purposes. Participants working in the city centre and commuting by personal car, would have provided more rich data relevant to the questions pertaining to the travel policy measures being implemented in the city centre.

The use of the COM-B model was not found to have been used widely in travel behaviour studies. Hence, implementing a model with relatively little literature proved challenging. The interview questions were chosen carefully to capture the capability, opportunity and motivational factors that influenced participants' travel choices as they transitioned from university education to the workforce. Consequently, the coding of the qualitative data was done only by the author, no independent analysis by a second researcher took place. Having a team of researchers could increase the confidence in the coding process and make findings more robust and less susceptible to a subjective bias.

A further limitation was the use of a hypothetical travel service. Even though participants were briefed and had the opportunity to ask questions on what MaaS was and how it worked, the actual comprehension of MaaS by participants was unknown. In addition, conducting interviews during a national lockdown required more clarification for which life stage the questions were being asked for. Thus, when participants were asked for their commute to work, they were reminded to answer with respect to pre-COVID or during COVID.

Chapter 7 Discussion and Conclusion

The motivation for this thesis was to understand young adults' travel behaviour as they transition from student to worker, and the factors influencing their travel choices to evaluate the potential use of MaaS. The use of MaaS implies the use of public transport and shared mobility services, which include transport modes strongly associated with students and less so with workers. The aim of this chapter is to present the key findings collected across Chapters 4, 5 and 6.

Understanding the travel behaviour of young adults is one of the key elements to promote the use of sustainable transport modes and to predict the future of travel behaviour. The studies conducted for this thesis have shown how most students depend on public transport and ridesharing services to travel. The use of such services, and the declining trend in driving licence and car interest, among young adults is attributed to living in urban areas, having less disposable income, and staying longer in higher education. The continuation of this declining trend is questioned as young adults move through life stages such as finding a full-time job which studies have found to result in an individual's first car purchase. This was indicated by most workers in this study driving to work using their personal car. The qualitative study shows how the transition from student to worker is characterised by a move away from public transport and towards the private car. Therefore, the importance of evaluating the potential use of MaaS among young adults lies in its ability to delay or reduce car dependency.

MaaS is a one-stop shop where the user has access to a variety of transport modes using a smartphone app. MaaS users can use the service either as pay-as-you-go or they can buy mobility packages based on their travel needs. One of the features of MaaS is the ticket and payment integration allowing the user to access all transport modes using one ticket. Thus, the availability of an integrated transport application that can match the convenience of a private car by offering a door-to-door journey can be thought of facilitating sustainable travel among young adults. This study found the potential MaaS users to be young workers in full-time employment which is supported by proponents of MaaS describing the average profile MaaS user as being young and making commuting and business trips (Jittrapirom et al., 2020). However, the use of MaaS by young adults is anticipated to be influenced by three key themes. Across the three empirical chapters, three key themes have been identified as influential for MaaS adoption.

Using a mixed methods approach, three key themes influencing mode choice were revealed from both the questionnaires and interviews. These were: social norms, time and effort and the financial cost of travelling sustainably. The following sections discuss the key findings in more detail in relation to mode choice among young adults transitioning from university – to – work. Following the discussion on the key findings, a discussion on the implications of this research for MaaS product designers, employers and policy makers is presented. This chapter concludes with a discussion of the challenges and limitations, recommendations for future research and conclusion.

7.1 Key findings

7.1.1 Social norms

Transport psychology recognises how social norms contribute to transport mode choice, which is often determined by complex interrelations of trip purpose, life situation, lifestyle, residential location, and urban form (Scheiner and Holz-Rau, 2010). Social norms is "rules and standards that are understood by members of a group and that guide and/or constrain social behaviour without the force of laws" (Cialdini and Trost, 1998, p.152). In this thesis, social norms were found to be influencing participants choice of transport mode in terms of friends and family using transport services as well as their perception of how easy or difficult using such services can be. This meant, participants' perceived ease of use of public transport and shared mobility was influenced by the opinions and experiences of their social network. Participants remarked how their lack of knowledge, skills, and experience in using public transport was influenced by their family and friends use of such services. Some participants remarked how their family never used public transport and how this had affected their knowledge and skills on how to use such services when required. Moreover, parents were also found to motivate participants into getting their driving licence. This is in line with a study conducted by Beirão and Cabral (2007) where the opinions of family discouraging the use of public transport influenced participants' perceptions of public transport use.

Individuals are not only influenced by social norms coming from their friends, family, and colleagues but also online through social media. The influence of social media on participants' mode choice should not be underestimated. In Chapter 6, two participants referred to environmentally conscious youtubers and environmental documentaries as influencing their approach towards a sustainable lifestyle. Other participants mentioned the convenient use of ICT to share their travelling plans with friends and to communicate their opinions about the use of certain transport modes. Overall, participants showed how they were reliant on smartphone travel apps when planning their journeys. As ICT continues to change the ways in which transport systems are perceived and used, ICT can play a major role in influencing young adults' modal choice. This is in line with a study by Allen et al. (2013) who show how young adults used online social networks to convince their peers to be more environmentally friendly, with such peer persuasion generating subjective norms that ultimately may influence behaviour. Similarly in their study Nah et al. (2019) found young passengers to be influenced by their friends' opinions and the public opinion on social media when deciding to use rideshare services. The impact that social networks have on travel behaviour change was shown in a study by Karatsoli and Nathanail (2021). The latter found an increased probability for students and full-time workers to change their mobility plans based on information provided by social media. This can be explained by the act of seeking approval from peers which is mentioned in the Theory of Needs by McClelland (1987). This suggests individuals have a propensity to exhibit a behaviour that is admired by their reference groups, as they seek relationships and group associations.

An individual's mode choice is not immune from the influence of others (Walker et al., 2011). In this study we found participants to engage in rideshare trips with friends that were in their social network. This was prevalent while participants were at university and less so when they transitioned into their work life. Ridesharing became more difficult because of the different work commitments, working in different locations and living further away from friends. Nevertheless, some participants did mention to try and organise rideshare trips with work colleagues when having to travel to the same destination. However, this was only successful with colleagues living in the vicinity. Universities and workplaces are represented by students and workers who form communities, providing them with the social opportunity to connect and share opinions that may influence each other's behaviour. Students are exposed to the opinions and value of their classmates and lecturers, which are then replaced by the opinions and values of their work colleagues as they transition into the workforce. Universities are known to play a fundamental role in promoting sustainability measures and practices through education and research, while preparing future generations for responsible actions towards sustainable development. However, this study found despite university websites displaying information on how staff and students can travel to university, most participants were not aware of the travel plans and travel schemes available by the university. To provide a coherent transition, it is beneficial to have the use of a travel plan at university as well as at the workplace. The management can influence an individual's choice of transport mode by using the right incentives and by committing to reducing their impact on the environment through their Corporate social responsibility strategy. The latter helps a company to create an environmentally conscious workplace. Companies should not only focus on reducing their carbon footprint through business travel but also through their employees' choice of transport to commute. This is where the concept of MaaS can be beneficial for companies to provide to their employees to use for both their commute and business travels.

Ultimately, the shift from using a private car to public transport is challenged by factors such as cost, and time as shown by the travel attributes in Chapter 5 that influence participants' mode choice. Participants who used public transport as well as their own car were found to more likely choose MaaS which allows them to use public transport and shared mobility services without taking away the freedom and flexibility they enjoy when using their car. This is in line with an argument by Moody et al. (2021) who found the non-use value of a car represented by the control, certainty, reliability, and flexibility that car ownership provides was higher than the incurred car costs. This means, people would value owning a car less when they have good quality public transport services (Moody et al., 2021). For MaaS to be appealing for car owners it would need to match the convenience of the door-to-door journey offered by the private car. This would be characterised by the time and effort required when making a trip.

7.1.2 Time and effort

Participants identified how their intention of using public transport and shared mobility services depended on how flexible and enjoyable the services were. The term flexibility is represented by the time spent inside or outside the vehicle, and enjoyable refers to the quality of the service. The results of the DCE show how both students and workers are sensitive to time and in the qualitative study an in-depth account for this sensitivity is explained by participants. As remarked by Viegas et al. (2016) in a report for The International Transport Forum, new shared transport systems need to be of superior quality in comparison to the current public transport system to facilitate users' adoption. Thus, transit operators need to focus on strategies and policies that improve the quality of the public transport services to remain competitive.

In the DCE, the strongest predictor of mode choice for both students and workers was walking time. This meant students and workers preferred transport modes with the least amount of walking time to access them. This was unexpected given how participants reported to be most attentive to the cost attribute when making their choice compared to the walking time attribute. However, participants sensitivity to walking time was supported by the qualitative study. During the interviews, participants mentioned how their travel choices would depend on the walking distance and the amount of planning involved. Participants chose to use travel modes conveniently located close to their home, place of work or university campus. For instance, a few participants said they chose to travel by train because their university had a train station on campus. Likewise, another participant said they commuted to work by bus because it took them right outside work whereas if they drove, they would need to park a 15 minutes' walk away. Therefore, participants' mode choice was influenced by the relative walking distance. Hence, many participants said how using their car was more convenient than public transport because they could just get in their car and drive, rather than having to walk to a bus stop or train station.

Planning public transport trips was found to be complicated and onerous for participants leading some participants to stick to their usual mode of transport when given a choice to change. However, workers who were train commuters were more likely to choose MaaS over the bus, and bus commuters were more likely to choose MaaS over the train. Nevertheless, the preference for the car remained high. Therefore, the shift to MaaS is mostly found among transport users who are flexible which is in line with proponents of MaaS describing the average profile of a MaaS users to be a flexible transport user (Jittrapirom et al., 2020). Hence, participants said something like MaaS would make it easier for them because the app would organise their trips automatically without any effort and according to their travel preferences. This is in line with Grotenhuis et al. (2007) who found the main determinants for using an integrated multimodal travel system were time savings in the form of travel and search time and effort savings in the form of physical, cognitive, and affective effort. Thus, participants hailed the use of smartphone travel apps in helping them organise their public transport and shared mobility trips. Such apps allowed participants to visually plot out their journey on a map, pay the travel fare (when provided) and check for any delays or cancellations using live travel time updates. For participants, ordering a taxi through an app was considered effortless and timesaving as they could immediately book a taxi if their public transport service was suddenly delayed or cancelled. Hence, participants claimed MaaS would be a convenient tool to have when ordering on-demand travel services, provided that MaaS subscription plans were flexible.

The importance of flexible MaaS plans stemmed from the complex travel needs of participants and time constraints. The expectation of participants to be on time for university lectures and for work, created a sense of pressure on participants, influencing their travel choices. Following a negative experience with public transport services, during their time at university, many participants chose to learn to drive and buy a car as they transitioned into the workforce. This was prevalent among participants who had work placements as part of their studies. Participants experience of public transport services included long commute journeys, delays, and cancellations and lots of planning with the need to wake up early. Participants explained how their travel experience made them think of how they could travel more efficiently and conveniently when they enter the workforce. The automatic reaction for participants was to learn to drive and buy a car as soon as they could financially. Thus, once participants stopped using public transport and started driving, they found driving to be effortless compared to using public transport. Participants discouragement from using public transport due to prior experience is in line with the results of a study by Beirão and Cabral (2007) where car users were discouraged from using public transport because of their previous experience of unreliable and infrequent public transport service.

In terms of time constraints, participants working schedules were found to influence their travel choices. Some participants said they could not use public transport for work even if they wanted to because their working schedule did not align with the public transport schedule. Therefore, their automatic choice was to use their personal car. However, one participant managed to change their working schedule for a few days until their car was being fixed. This experience shows how flexible working schedules can shift workers towards the use of public transport. This was revealed in a study by Pnevmatikou et al. (2015) conducted in Athens, Greece. The authors found participants with flexible work schedules less likely to use the car as an alternative mode of travel during metro closures. This means a flexible work schedule would allow workers to make use of public transport services without stressing over the time they need to be at work.

7.1.3 Financial cost of travelling sustainably

People’s use of public transport and shared mobility services is not only influenced by the quality of the service but also by their personal capability and intrinsic motivations. In this study, although some participants hailed the usefulness of transport online platforms such as Uber as a backup for when public transport services were delayed or cancelled, the cost of using such transport services was not considered to be feasible in the long run. Therefore, participants considered MaaS would make such on-demand travel services to be affordable as part of a travel subscription. Otherwise, participants’ automatic motivation was to shift from public transport and shared mobility services to a private car as soon as they were financially stable. Nevertheless, the aim of MaaS is to provide an alternative to the dependency on car ownership by matching the convenience, flexibility, and reliability of owning a car but at a cheaper price. In their study, Abrahamse and Steg (2009) found contextual variables such as income shape households’ opportunities for energy consumption, whereas reductions in energy use require conscious efforts to adopt energy saving measures (Abrahamse and Steg, 2009). This was also found by Perera et al. (2020) studying the potential for the Demand Responsive Transit (DRT) operations in Sydney. The authors concluded for the DRT to facilitate a modal shift away from private vehicles it needs to be affordable and well regulated. Therefore, providing affordable subscription plans and improving the quality of the service with frequent and accessible services provide travellers with the opportunities to become MaaS users.

In the qualitative study, although there was no specific cost related question within the interview guide, cost as an influencing factor appeared in most participants' responses. The interviews show how participants' mode choice was determined by its cost particularly when they were students, but even as employees, participants said they would not mind saving money on their commute. The DCE results show both workers and students were sensitive to cost showing their preference for inexpensive transport modes in comparison to their current transport mode. This means students made their choice using walking and the cost of a discounted travel subscription as reference points. Hence, students were found to prefer the bus more than the other more expensive transport modes of; train, MaaS and private car. Whereas workers made their choice using the cost of the private car as a reference point. The results show workers to prefer the private car more than MaaS and the train, with the least favourite being the bus.

Participants in the qualitative study who were employed full-time said their choice not to buy a car and walk to work or use public transport occasionally was to save up money for a master's degree. Studies have reported how participation in higher education delays car ownership (Chatterjee et al., 2018) mainly because of a delay in employment (Zhong and Lee, 2017). However, in this study participants choice not to own a car was not because of being unemployed but because they prefer investing in furthering their studies rather than in purchasing a car. Studies have shown that millennials are pursuing post-secondary education at rates higher than any other generation in history and are also more economically dependent on parents than their previous generation (Klein and Smart, 2017, LendingTree, 2016) Nevertheless, participants who had no financial commitments chose to buy their car as soon as they were financially stable. Soon after purchasing their car, participants acknowledged how car ownership increased their expenses as they needed to pay for parking fees and petrol costs. Thus, one of the main reasons for participants to rideshare was to split fuel costs and parking costs.

With reference to MaaS, participants chose to explain their preference and potential use for MaaS in terms of financial cost. Although participants acknowledged how MaaS may have a premium price considering the services it offers, MaaS would need to offer a competitive price in comparison to the existing train and bus subscriptions for its potential uptake. Moreover, participants were found to be interested in using MaaS if it offered them customised subscription packages according to their financial budget. Otherwise, participants said they would find a pay-as-you go option convenient for them. To make MaaS appealing, participants suggested the use of financial incentives such as travel and retail discounts. These results are consistent with the semi-structured interviews conducted by Alyavina et al. (2020) in London, Birmingham, and Huddersfield. The results show how cost was the most critical factor for the uptake of MaaS with participants suggesting incentivising users via the app.

7.2 Implications for MaaS product designers, employers, and policy makers

This section provides several insights that MaaS product designers, employers and policy makers need to consider when promoting MaaS for students transition to the workforce. Policy makers have focused on implementing measures that make travel by car slower, more expensive, and less convenient to encourage a shift towards the use of public transport and shared mobility services (Buehler, 2011). The insights discussed below were elicited from participants' travelling in the West Midlands and particularly within the metropolitan city of Birmingham. This means the policy interventions and regulations discussed in this section can be inapplicable to other regions with different travel infrastructure and characteristics.

7.2.1 Appealing features to aid with MaaS adoption

Despite most participants reporting that they had never heard of the concept before, they showed great interest in how MaaS could work for them. Participants' knowledge and skills of previous smartphone travel apps made it easier for them to recognise the benefits of MaaS compared to the current travel planners. The most important feature for participants was the integration of all transport modes and payment systems into one single app. The availability of on-demand services such as ridesharing, carsharing and taxi, integrated with public transport services was considered a much-needed feature by participants. Participants with experience using public transport said it was inconvenient for them having to access different websites and buy tickets from different train and bus operators when organising their trips and emphasised the importance of app functionality especially when they need to use the app on the go and when experiencing service delays or cancellations. Participants who had experience with using smartphone travel apps said they lost interest after the app started to malfunction. Most of the time the main issue was the incorrect travel time updates and the payment function of the app. Displaying correct time travel services was considered crucial for participants who needed to use more than one transport mode to get to their destination as otherwise displaying incorrect travel time updates could result in participants missing their connection. This could be compared to how participants negative experience with public transport services made them lose interest in using such services, and ultimately replace the use of public transport with the private car.

Other in-app features which participants said they would like to see in a MaaS app were features which Google Maps currently offers. For example, information on how busy a service stop was and whether the service had any available seats. These are features which participants said they would find useful when making their travel choices. This is in line with Andersson et al. (2020) who observed how travellers using smartphone travel apps expect the app to tell them how to get to the station or stop, what the station or stop looks like, what service is offered and where and how the exchange itself can be done. However, another in-app feature which this thesis found to determine participants' mode choice was a safety feature. Participants said they would be willing to use MaaS if it could provide them with in-app features where they could share their location with third parties and find profiles of drivers and rideshare users. Safety was found to be an issue for participants when choosing to use shared mobility services. This was revealed in a study by Cruikshanks et al. (2013) who found rideshare initiatives to prove difficult to operationalise in the UK due to the safety concerns of travelling with strangers. Therefore, participants emphasised the need for in-app safety features for them to feel at ease when using public and shared transport services.

The willingness to use MaaS by participants was mainly related to how convenient, reliable, affordable, and flexible the service can be to their travel needs. Most participants said MaaS would be beneficial to use for specific travel purposes. Non-car owners said MaaS would be useful for both work and leisure travel purposes given how they substituted car ownership with the use of rideshare or taxi services. Whereas car owners believed MaaS would be useful when travelling into the city centre of Birmingham, for which most participants said to visit for leisure purposes and mainly by public transport services. The lack of parking spaces, parking fees and congested roads in the city centre make MaaS appealing for car owners to use. Thus, given the different travel purposes, MaaS subscription plans would need to be flexible. The latter would involve the user to choose which transport modes they prefer and the number of rides they need for each transport mode which would fit within their financial budget. To attract users towards MaaS, participants suggested the inclusion of rewards and retail discounts. This was revealed by a participant's experience of trying Uber. The latter offered students a discounted price whenever they had a friend who used the service. Hence, the use of Uber among students was encouraged by their peers through word of mouth so that everyone can take advantage of the student discount. This is consistent with Ho et al. (2020) who argue the inclusion of discounts and rewards for travelling sustainably would guarantee the widespread adoption of MaaS.

The in-app features, app functionality and flexible subscription plans were found to be crucial for participants when evaluating their willingness to potentially use MaaS. It is recommended for MaaS product designers as well as operators to understand and meet the needs of their customers especially young adults as they move through different life stages. Travel needs such as work schedules and travelling to different locations for leisure and work commitments can lead to challenging travel requirements. This is in line with Araghia et al. (2020) who argue how MaaS needs to provide fast, accurate and real time support for travellers as transport users become more demanding for faster, more frequent and more travel options.

7.2.2 Workplace policy interventions to aid with MaaS adoption

Most participants surveyed in this thesis drive to work and therefore to shift employees towards more sustainable transport modes workplaces incentives and interventions will be needed. In this study, the reasons for workers to commute by car to work were specific to cost, parking availability, work culture and time constraints. Thus, for workers to acknowledge the benefits of using MaaS for their commute to work, organisations need to implement several incentives and dis-incentives to present MaaS as a viable option to the car.

In the qualitative study, participants remarked how as students they had more opportunities to use public transport and shared mobility services at discounted rates. Participants suggested how a subsidised public transport subscription should be available to workers similar to how these are available for students, to encourage them to use public transport services. Nevertheless, the availability of discounted travel subscriptions and travel schemes should be promoted more to ensure employees are equally aware of the travel options available. In this study, most participants were found to lack knowledge on the available travel schemes. Only a few participants out of personal interest knew about the cycle to work scheme and corporate travel cards offered by their employer. The qualitative study shows how there is a need for workplaces to promote travel schemes and encourage their employees to share their opinions on how employees can be helped in travelling sustainably. In Chapter 6, in an interview with the head of sustainability at a professional services company in Birmingham there was a suggestion that employees could make a request to the company for a particular travel scheme. For instance, if a group of employees want their employer to subsidise their MaaS subscription they could make a request and if there would be pressure on the management, then the request can be addressed. This is consistent with the findings of Busch-Geertsema and Lanzendorf (2017) who found job starters in possession of their student transport subscription to continue commuting by public transport as opposed to job starters who did not have a student transport ticket. Moreover, the authors acknowledged how more people requesting a public transport subscription would put pressure on companies to provide it.

Nevertheless, for the uptake of alternative travel modes via the use of MaaS, companies would need to foster a culture that encourages environmentally friendly behaviour. Participants explained how their workplaces were not doing enough to promote sustainable travel. Something which car owners said puts them off driving into the city centre was the lack of parking spaces and parking fees. Likewise, participants who could drive to university said they were discouraged by the expensive parking fees the universities imposed. The decrease in parking spaces and increase in parking fees at the workplace can lead to a reduction in car use. This is consistent with a study by Christiansen et al. (2017) who studied parking spaces as an intervention at a workplace in Norway. Christiansen et al. (2017) found the probability of employees using their car for travelling to work would be lower if both the reduction of parking spaces and the implementation of the parking charge were combined. This was found after implementing parking charges without decreasing the number of parking spaces failed to achieve a reduction in car use to work (Christiansen et al., 2017). Other issues with parking were noted in terms of walking distance, one participant said to prefer commuting to work by bus because the car park was located a 15-minute walk away compared to the bus stop which was just outside their workplace.

Workplaces can incentivise employees to rideshare by offering dedicated parking spaces to rideshare users. Although participants said they would not choose to rideshare with strangers, they did not exclude ridesharing with work colleagues. Rideshare incentives could also include organisations covering employees fuel costs. Nevertheless, the success of these incentives in encouraging rideshare among employees in a corporate environment depends on ridesharing matching the convenience of the private car. This was revealed in a study by Hesselgren et al. (2020) who studied the implementation of MaaS in Sweden among 14,000 employees. Their study found two thirds of the employees that used to commute by car continued to travel by car because neither public transport nor MaaS appeared to offer or support competitive alternatives for their commute. This was explained by the availability of free parking at the workplace which conflicted with the use of MaaS. Therefore, the workplace needs to provide a working culture that promotes ridesharing and discourages single occupancy vehicles.

To promote the use of sustainable transport modes, workplaces can appoint individuals in the workplace as 'environmental champions'. As previously discussed, the opinions and values of work colleagues can influence an individual's travel behaviour. As students transition to the workforce, they become exposed to opinions and values different to those perhaps experienced at university. These new social connections can lead to a change in travel behaviour. Thus, Raineri and Paillé (2016) found the pro-environmental behaviour of employees to be influenced directly by co-workers and indirectly by supervisors and the organisation. Therefore, providing an environmentally friendly workplace culture can influence employees' environmental behaviours.

Another reason why participants in this study were discouraged from using public transport to commute to their workplace was because of their working schedule. The expectation of participants to be on time for work in the early hours of the morning meant participants could not use public transport because the service would not yet be available. Utilizing a flexible work schedule policy would allow employees to modify their arrival and departure times to better align with public transport service schedules. This was demonstrated by one of the participants in the qualitative study who communicated with their manager to shift their working hours so they could get to work by public transport. This is consistent with the belief of Guzman et al. (2020) that the social dialogue between employers and employees plays a relevant role in changing commute behaviour. However, the literature available on the impact of flexible work schedule with shifting towards sustainable travel modes are conflicting. In a study by Islam and Habib (2012) flexible office hours in Switzerland found full-time employees to increase the preference for the car. Whereas Tahmasseby et al. (2016) found flexible work schedules to encourage ridesharing among students and staff at the University of Calgary, Canada. Thus, the impact of flexible work schedule needs to be further studied. Nevertheless, employees on non-flexible working schedules can still benefit from the use of MaaS as it offers shared mobility services such as ridesharing and taxis which do not follow a strict transport schedule. Studies believe such services complement existing public transport services (König et al., 2018) potentially substituting local scheduled buses.

Overall, workplaces have a fundamental role in encouraging the use of sustainable travel modes especially for new employees. Workplaces need to provide incentives that encourage employees to commute by public transport and shared mobility services, especially with the intake of new employees. This is in line with Clark et al. (2016) who found people were more likely to change commuting behaviour when they start working for a new employer and policy measures are likely to be most effective when aimed at new employees. Therefore, having a culture that encourages environmentally friendly behaviour, making sustainable transport accessible and establishing a sustainable travel policy would be beneficial to have within organisations (Andersson et al., 2020).

7.2.3 Government policy measures

A few participants in Chapter 6 were found to be knowledgeable on the government cycle to work scheme either from colleagues or their own personal initiative when looking for alternative travel modes on their employer's website. In Chapter 6, the head of sustainability at a professional services company in Birmingham in an interview reported that despite the success of the cycle to work scheme at their workplace, the complicated application of the scheme was putting pressure on their corporate operations in issuing such schemes. Thus, government policy incentives promoting sustainable travel should be more streamlined and easier to apply to, for employers to confidently promote the scheme with their employees.

During the progress of this thesis, the City of Birmingham implemented a CAZ which was launched as from June 2021. This meant non-compliant cars are charged £8 daily when driving into the city centre. Given the aim of the CAZ is to improve the air quality in the city centre by shifting car drivers towards alternative modes of travel, participants anticipated public transport services to become busier as people are encouraged to use public transport. Therefore, participants said they would expect the authorities to respond efficiently to the demand. Consequently, providing good quality public transport and shared mobility services would make MaaS more appealing to the public.

Prior to the CAZ, participants who were car owners said it was always much easier and cheaper for them to use public transport when visiting the city centre compared to driving. Consequently, knowing the CAZ would impose a daily charge, participants said they were even more convinced that they would be sticking to public transport, unless they rideshared to split the costs. Non-car owners did not anticipate for the CAZ to significantly impact their travel behaviour unless they were using taxis or an Uber. Participants believed such services would increase in price because of the daily charge. Hence, the availability of a MaaS app to incorporate taxi use together with public transport would make it easier for travellers to use different transport modes without worrying on the different prices of each mode.

In addition to the CAZ charge, the City Council was implementing a Traffic Cells Initiative. The latter segments the city centre into six areas restricting vehicle access from one area to another. Drivers would need to access each area using the outer ring road. Considering this, participants using taxis, Uber or their personal car said their journey time would likely increase. As shown by the results in Chapters 4, 5 and 6, participants were sensitive to time. Thus, participants were conscious of travel time and preferred transport modes which were faster. Travel time was also found to be an important factor when participants were looking for work. Long commute times for participants meant loss of time and money. Therefore, implementing the Traffic Cells Initiative to slow down car journeys and let public transport be unaffected, made participants perceive public transport services to be quicker than driving. Thus, participants anticipate MaaS could help them navigate public transport and provide them with the quickest journey without the need of using a car. Moreover, participants believe MaaS would be helpful for people from outside of the city and who might not be familiar with the transport system of the area. For instance, participants recalled how visiting places which they were not familiar with made it difficult for them to use the local public transport and shared mobility services. Therefore, having an app like MaaS would make it easier for visitors to navigate the city using sustainable travel modes. Likewise, this would prove beneficial to have extended to other regions in the UK to make travelling across regions more effortlessly.

7.3 Challenges and limitations

Although the results and findings obtained in this thesis provide novel insights into the travel choices of students and workers, they are not exempt from limitations and challenges.

7.3.1 Defining MaaS

The first challenge was predicting the adoption of MaaS which as a concept is still in its infancy and a commonly agreed definition is not yet available. Thus, the definition for MaaS for this study was created from the core characteristics of MaaS provided by Jittrapirom et al. (2017), the description of the MaaS app ‘Whim’ by MaaS Global and the definition of MaaS provided by the UK Parliament following a call for evidence (UK Parliament, 2018).

Another challenge was defining and describing MaaS to participants. A description of what MaaS was and how it works, was carefully created to communicate the core characteristics of MaaS. Visual images and screenshot examples from the Whim app were used to create a visual explanation of what a MaaS app would look like and how it works. The visual explanation was tested with young adults to ensure the text and visual images were comprehensive. Another method which could have been used was to create a short video clip demonstrating the MaaS concept. Creating a high-quality video would have required a large amount of time, skills, and financial resources. Taking this into account, a visual explanation of what MaaS is and how it works was considered a suitable solution.

In each of the empirical chapters, participants were either asked about their thoughts on MaaS (Chapter 4, Chapter 6) or to make a choice between MaaS and other conventional transport services (Chapter 5). Prior to answering such questions, participants were provided with a visual explanation. In Chapters 4 and 5, participants had to correctly answer several multiple-choice questions testing their knowledge on MaaS, before proceeding with the rest of the questionnaire. However, the level of comprehension by participants was unknown. In Chapter 6, participants had the chance to ask questions of the researcher to verify their understanding of MaaS. Some of the questions asked were if the service was available and if a MaaS subscription could include the services of Uber. The concept of an integrated subscription service was well understood with many participants choosing to liken it to smartphone travel apps such as Google Maps and Uber. Hence, to improve the understanding of MaaS a short video clip would have been helpful for participants to have a working understanding of MaaS.

7.3.2 Design and data collection

The design and data collection for each of the methods used (questionnaire, discrete choice experiment and interview guide) had several limitations. These limitations impact the quality of the collected data and should be considered when interpreting the results. In Chapter 4, participants were asked for their intention to use public transport services and shared mobility services for everyday trips. Two limitations were found. First was using a behaviour of interest that captures two different travel purposes for work and leisure. The behaviour of interest asked participants about their intent of using public transport and shared mobility services for their everyday activities meaning both their work and leisure activities. The decision to include all types of activities was to encompass both commuting and non-commuting trips which ideally can be covered by a MaaS subscription plan. However, this might have affected participants responses as travellers are known to use transport modes according to their trip purpose (Delbosc and Nakanishi, 2017). Therefore, future studies should focus on evaluating the use of MaaS for particular trip purposes. This is supported by the results in Chapter 6 which found one of the key determinants for participants to use MaaS was travel purpose. The second limitation was the definitions used for the shared mobility services. Despite the shared mobility services of carsharing, ridesharing and bike sharing were defined and tested prior to distributing the study, during the interviews in Chapter 6 it transpired that some participants confused ridesharing with carsharing. Therefore, this confusion could have influenced participants understanding and potential use of these services when stating their intent of using such services. To overcome this limitation, it would be helpful to use hypothetical journeys as examples of shared mobility services to explain how an individual can use ridesharing, carsharing and bike sharing services.

The use of a discrete choice experiment (DCE) in Chapter 5 had several limitations and challenges. The use of a DCE was appropriate for this study given that a hypothetical scenario was used, however one of the main limitations of stated choice experiments is they only record choices made in hypothetical scenarios (Fifer et al., 2014). This produces different types of biases such as inattentiveness, attribute non-attendance and incongruity with actual (revealed preferences) behaviour (Danaf et al., 2019). Despite overcoming the limitation of attribute non-attendance by asking participants to rate their level of attentiveness for each travel mode attribute, the results revealed a discrepancy in what participants declared to have been attentive to and the results of the random choice utility model. Participants said they had always considered the cost when making their choice, but the coefficients of the travel mode attributes show participants made their choice based on the walking time. The findings of the stated DCE can be improved using a revealed choice experiment. Revealed choice experiments use data from actual behaviour which would also provide more robust WTP estimates (Danaf et al., 2019). Furthermore, the WTP estimates were found to be much higher compared to other studies using stated choice experiments on mode choice. Therefore, it would be helpful to conduct a revealed choice experiment using a MaaS trial to produce robust WTP estimates.

Another limitation in Chapter 5 is related to the presentation of the travel zones covered by the bus, train and MaaS alternatives. To show participants the travel zones covered by each alternative, a link was embedded within the title of each alternative to make it easier for participants to access the travel maps. Participants were made aware of the available transport maps by being instructed to click on the titles of each alternative to reveal the maps. The level of comprehension was unknown and participants who were familiar with the public transport travel zones would have had a better understanding of the travel area covered by each alternative. This could have been improved by dedicating a section within the questionnaire showing and describing each map prior to participants starting their choice tasks. However, this would prolong the time for participants to complete the questionnaire and could result in several participants dropping out. But then again, it would give each participant the same chance of seeing the transport travel zones.

Finally, the findings of this thesis are specific to the West Midlands particularly the metropolitan region of Birmingham. Therefore, the results could differ if the study was replicated in another region in the UK and generalised to the wider population.

7.3.3 Participant recruitment

The recruitment of participants for both the TPB questionnaire and the interviews relied heavily on social media. Thus, social media users with an interest in changing their transport mode or interested in smartphone travel apps, might have been more inclined to participate in this research. The recruitment of participants through convenience sampling led to self-selection bias. This could result in participants recruited for the study to have different sociodemographic characteristics and travel behaviours compared to the general population.

7.3.4 Clarifying travel behaviour questions during a pandemic

A definite challenge for this thesis was collecting travel behaviour data during a global pandemic where people were instructed to avoid public transport and all social activities were put on hold. Research studies reported how the pandemic had changed travel behaviours worldwide (Eisenmann et al., 2021, Awad-Núñez et al., 2021). Thus, data collection procedures had to include an additional element of clarifying questions to respondents whether they were being asked about their travel behaviour pre-pandemic or during the pandemic.

7.4 Recommendations for future research

Ideas for future research have been drawn from the recommendations and limitations of this research. The concept of MaaS is still in its infancy and more research on this subject is being published at the time of writing. Research is needed to explore how the adoption of MaaS can be accelerated by exploring the factors that make MaaS appealing as well as by assessing the readiness of individuals to adopt MaaS. Firstly, focusing on the students and workers most likely to adopt MaaS, i.e., flexible transport users, studies are needed to assess the type of

MaaS subscription, or pay-as-you go option for such commuters. Replicating studies by Caiati et al. (2020), Ho et al. (2018, 2020) and Matyas and Kamargianni (2019), would elicit users' preference of MaaS bundles specifically for the West Midlands. Efforts need to be made to include a range of transport modes to provide a more comprehensive view into the attractive MaaS options for students and workers.

Secondly, this study found that both students and workers are willing to use MaaS according to their work and leisure travel purposes. It would be beneficial to explore the optimal subscription plans for leisure and work travel purposes for different types of commuters. Ho et al. (2020) emphasised the need for studies to examine groups with different commuting purposes when studying the demand for MaaS and in this study, the homogenous characteristics of age, living arrangements and commute distance for the student sample made it difficult to recognise different travel patterns. Therefore, further research should be conducted on young adults' travel behaviour patterns as they have unique travel needs and challenges. Moreover, they are the next generation of urban commuters and will define the services and requirements for future urban transport systems (Habib et al. 2018). This could be extended further into an observational study where a group of workers and students can trial a MaaS subscription plan for a period. This would allow researchers to explore the impact of MaaS on car use behaviour and use of public transport and shared mobility services, like the few available MaaS field trials in Sweden by Sochor et al. (2014) and in Sydney by Ho et al. (2021).

Thirdly, implementing behavioural interventions can be complicated given the contextual differences that necessitate the development of tailored and evidence-driven interventions. Finishing university and starting a job are key life events that have been marginally investigated (Müggenburg et al., 2015). This study found the transition from university education to the workforce led to changes in participants' travel choices. Therefore, more studies are needed to explore this life stage vis-à-vis the types of behaviour change interventions that can have an impact on mode choice. Such interventions can be designed using the BCW by Michie et al. (2014). In this thesis the COM-B model which sits at the core of the BCW, was used as a behavioural framework, however the results of this study can be further analysed to design and implement an intervention function which serves the travel needs of students transitioning into the workforce.

Finally, future research must continue to monitor the CAZ and Traffic Cells Initiative in Birmingham and its influence on travellers' mode choice when visiting the city. This study found the implementation of a charge to enter the city centre and restrict driving from one area to another would prove influential in changing participants travel behaviour. The role of MaaS considering these travel restrictions into the city centre would prove beneficial to assess how the uptake of MaaS can be accelerated. Hence, studies combining the role of MaaS, and travel policy measures can reveal which travel policy measures would be influential in the uptake of MaaS.

7.5 Conclusion

The overarching aim of this thesis was to provide empirical evidence on the potential adoption of MaaS for the life stage transition between student and work life. Three main research questions focused on understanding the potential uptake of MaaS for students transitioning into the workforce. MaaS is a hypothetical concept which implies the use of public transport and shared mobility services through a digital interface and subscription service. The first research question aimed to determine whether students and workers commuting in Birmingham fit the MaaS characteristic profile. This was achieved using the assessment of multimodal travel behaviour among commuters and their intention to use public transport and shared mobility services. Multimodal students were found to switch between public transport modes and shared mobility services, whereas workers were most likely to switch between their private car and public transport or shared mobility services. Due to the homogenous characteristics of age, car ownership and commute distance, the study did not find different behaviour patterns for students. Whereas multimodal workers were found to be younger in age, employed full-time and commuting 13 miles or less. The intention to use such services for both groups was influenced by their significant others using such services and their level of confidence in navigating public and shared mobility services. The intention for both workers and students to use such services was found to increase when public transport and shared mobility services were perceived as pleasurable, convenient, safe, and providing an overall good experience. The only variable not found to be statistically significant in explaining intention was controllability. Thus, PBC can be said to have a second role in explaining the relationship between intention and behaviour. However, as argued by Ajzen (2020), since both workers and students reported to have strong beliefs in performing – or not – performing the behaviour, control over the behaviour was considered irrelevant.

The second research question focused on measuring the uptake of MaaS by identifying the most important travel mode attributes for students and workers. Something which other studies have not yet done (as at the time of conducting and planning this study) is the inclusion of MaaS, among other established transport modes, in a stated DCE study. The results of this study, although confirm the well-known importance of cost and travel time in determining mode choices, the particular attributes influencing mode choice are still somewhat different where cost plays a lesser role and walking time is considered to be more influential. The results show both students and workers prefer cheaper and faster transport modes to get them to their destination with minimal walking time. In general, the model results answer the questions this study set out to explore aiming to position MaaS in the transport market and understanding the sensitivity of travellers towards instrumental travel attributes: travel time components, travel cost, socio-economic variables, and travel characteristics. Some similarities were observed between the two groups, where they were sensitive to cost and time, but the preference for the private car was the highest for workers. Meanwhile, there was no difference in preference when students were faced with a choice between travel modes if their travel attributes were identical. Students from low-income households and participants in part-time employment were more likely to choose a bus monthly subscription over a MaaS subscription. When given a choice, several participants chose the same transport option as their usual commute mode. However, public transport users showed they were flexible in their use of transport modes. This means anyone using the bus or train to commute, they are likely to choose MaaS which provides them with a range of transport modes that can serve different purposes and stages of their journey. Proponents of the MaaS concept claim that subscriptions to alternative modes can effectively reduce car ownership. However, this was only found for workers who commute by train and students with a public transport subscription, to prefer MaaS over the private car. Moreover, workers who had experience in booking and paying for public transport and taxi services using their smartphone were more likely to use MaaS over the car. Thus, MaaS potentially acts as an alternative to the current public transport system for both students and workers. MaaS is competing with established transport subscriptions and the private car, and therefore the results of this study show how MaaS in the current market needs to be mindful of cost and travel times when designing subscription plans and journeys for their subscribed members.

The third research question used a qualitative approach to gain a deeper understanding of the specific factors influencing young adults travel choices. In addition, the study sought to evaluate the impact of the transport policy measures implemented in the city centre of Birmingham and the potential use of MaaS. To the best of the author’s knowledge, this study was one of the first attempts to use the COM-B model in the transport sector within the context of life transitions. Using semi-structured interviews, participants recounted how they used to commute to university and how their travel behaviour had changed, or was kept the same, when they started their graduate job. Several themes emerged which may hold the key to supporting young adults use of sustainable transport modes as they start their graduate job. The results found students use of public transport and shared mobility services during university influenced their travel choice as they transitioned into the workforce. The negative experience of unreliable services coupled with the lack of public transport networks and time constraints at the workplace led students to shift away from public transport and start driving as they transitioned into the workforce. However, both students and workers chose to use public transport services to travel into the city centre due to the lack of parking spaces, parking fees and road traffic. With the implementation of a CAZ and Traffic Cells Initiative restricting car use in the city centre, participants believed using public transport would be the easiest and cheapest way to travel to the city centre. Moreover, this would be a sensible time to introduce a product such as MaaS where the aim is to help the user navigate the available public and private transport services and provide customised travel plans at affordable prices.

This thesis provides valuable insights into the contributing factors to the choice between current transport modes and the new MaaS travel concept. The results present a better understanding of the potential market for MaaS and highlight the underlying problems that have significant influences on choice behaviour. The findings in this study can help policy makers to understand the market potential for MaaS in the era of digital transport technology. Individuals with specific characteristics such as commuters who have experience booking and paying for services using their smartphone, low-income individuals, or those who currently travel by public transport, probably are willing to continue using public transport, unless MaaS becomes much more attractive in relation to cost, efficiency, customised plans, and overall good service quality.

The findings reported in this thesis show potential for MaaS to be used as a sustainable tool to help delay the purchase of a car by students transitioning into the workforce. However, the success of adoption is predisposed to social influences, the capability of an individual to navigate smartphone travel apps, the convenience of a door-to-door journey like the private car and the cost of a subscription which takes into account the users' financial budget. The adoption of MaaS by young adults can be supported by national and local governments, educational institutions and corporations through financial incentives, good quality public transport infrastructure, and a work culture that encourages the use of sustainable transport modes. Road transport accounts for 10% of global emissions, and its emissions are rising faster than those of any other sector. A shift to zero emission vehicles is already underway however a shift away from car ownership to public transport and shared mobility services is needed. The use of low and ultra-low emission zones in London and the CAZ and Traffic Cells Initiative in Birmingham, discourage drivers from using their private cars leading to reductions in roadside emissions. This is where MaaS comes in as a potentially sustainable travel tool to make it easier for travellers to leave their car at home and use alternative modes of transport.

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Appendix A

Filter Question

Could you be one of the early adopters of a new digital transport service?

Your participation in this study will involve learning about a new digital transport service and answering questions on:

- your travel habits,
- your access to transportation services, and
- attitude towards using shared transport services.

At the end of the survey you will be asked to provide your preferred contact details to be included in a prize draw with a chance to win one of five Amazon vouchers (£50, £40, £30, £20, £10).

The survey will approximately take 10 minutes or less, but please note that there is no right or wrong answer, and so we encourage you to answer honestly. Your answers will influence and shape the potential of this new digital transport service.

All data used in the study will be held anonymously and securely. Only the researcher and the research team at the University of East Anglia will have access to the data collected, and that this data will be held securely for a period of 3 years (the duration of the project) and then destroyed.

This study has gained ethical approval from the General Research Ethics Committee at the University of East Anglia, Norwich, UK.

You can choose to stop participating at any time by contacting the researcher Ms. Emma Cassar (e.cassar@uea.ac.uk).

Please complete the survey and at the end you will be asked for your preferred personal contact to be in the chance to win one of five Amazon vouchers. Your participation and contribution to this study are highly important and we extremely appreciate your help.

By clicking 'Yes' to take the survey, I consent to participate in the survey and for my data to be used for its stated purpose.

○ Yes
○ No

Which of the following best describes your status?

I am...

○ a fulltime student attending a university in Birmingham
○ currently employed in Birmingham
○ None of the above

Travel Behaviour Student

During the previous month, for all types of activities, including weekdays and weekends, which of the following means of transport did you use to travel to or within Birmingham?

☐ Bus
☐ Tram/Metro
☐ Train
☐ Car driver (private car)
☐ Car share (passenger or driver)
☐ Car passenger (private car)
☐ Walking
☐ Bicycle (private)
☐ Bicycle (bikesharing scheme/bike hire)
☐ University Free Shuttle Bus
☐ Taxi/minicab
☐ Uber (on-demand ride services)
☐ Coach
☐ Park and Ride
☐ Motorcycle/moped

How often have you used each of the following means of transport during the previous month?

	Everyday	5-6 days a week	3-4 days a week	1-2 days a week	1-3 days in a month
Bus	○	○	○	○	○
Tram/Metro	○	○	○	○	○
Train	○	○	○	○	○
Car driver (private car)	○	○	○	○	○
Car share (passenger or driver)	○	○	○	○	○
Car passenger (private car)	○	○	○	○	○
Walking	○	○	○	○	○
Bicycle (private)	○	○	○	○	○
Bicycle (bikesharing scheme/bike hire)	○	○	○	○	○
University Free Shuttle Bus	○	○	○	○	○
Taxi/minicab	○	○	○	○	○
Uber (on-demand ride services)	○	○	○	○	○
Coach	○	○	○	○	○
Park and Ride	○	○	○	○	○
Motorcycle/moped	○	○	○	○	○

What is the main form of transport you normally use for your journey to university? If you use more than one means of transport, please choose the one with which you travel the longest distance.

If you do not see your means of transport below, go back to the question with a list of means of transport and select it. You will not lose any answers in the process.

○ » Bus
○ » Tram/Metro
○ » Train
○ » Car driver (private car)
○ » Car share (passenger or driver)
○ » Car passenger (private car)
○ » Walking
○ » Bicycle (private)
○ » Bicycle (bikesharing scheme/bike hire)

○ » University Free Shuttle Bus
○ » Taxi/minicab
○ » Uber (on-demand ride services)
○ » Coach
○ » Park and Ride
○ » Motorcycle/moped

When travelling to university, do you normally use more than one form of transport within the same journey? (example taking the train first then catching the bus to university, exclude walking)

○ Yes
○ No
○ Don't know

Within an average week (Monday to Sunday), how many times do you travel to and from university? (a return journey counts as 2)

From where you currently live, how long is your typical journey to University in terms of:

Journey duration to University (enter number in minutes)

Journey distance to University (enter number in miles)

From where you currently live, are public transport services available within walking distance?

○ Yes
○ No
○ Don't know

How often does the public transport service run from this stop?

○ Every few minutes
○ More than once an hour
○ Several times per day
○ Only a few times per day
○ Don't know

Travel Behaviour Graduates

During the previous month, for all types of activities, including weekdays and weekends, which of the following means of transport did you use to travel to or within Birmingham?

☐ Bus
☐ Tram/Metro
☐ Train
☐ Car driver (private car)
☐ Car share (passenger or driver)
☐ Car passenger (private car)
☐ Walking
☐ Bicycle (private)
☐ Bicycle (bikesharing scheme/bike hire)
☐ Work provided Shuttle Bus
☐ Taxi/minicab
☐ Uber (on-demand ride services)
☐ Coach
☐ Park and Ride
☐ Motorcycle/moped

How often have you used each of the following means of transport during the previous month?

	Everyday	5-6 days a week	3-4 days a week	1-2 days a week	1-3 days in a month
Bus	○	○	○	○	○
Tram/Metro	○	○	○	○	○
Train	○	○	○	○	○
Car driver (private car)	○	○	○	○	○
Car share (passenger or driver)	○	○	○	○	○
Car passenger (private car)	○	○	○	○	○
Walking	○	○	○	○	○
Bicycle (private)	○	○	○	○	○
Bicycle (bikesharing scheme/bike hire)	○	○	○	○	○
Work provided Shuttle Bus	○	○	○	○	○
Taxi/minicab	○	○	○	○	○
Uber (on-demand ride services)	○	○	○	○	○
Coach	○	○	○	○	○
Park and Ride	○	○	○	○	○
Motorcycle/moped	○	○	○	○	○

The following questions are about how you travel to your workplace.

Do you work from home rather than commuting to your workplace?

○ Yes, always
○ Yes, sometimes
○ No, never

What is the main form of transport you normally use for your journey to work? If you use more than one means of transport, please choose the one with which you travel the longest distance.

If you do not see your means of transport below, go back to the question with a list of means of transport and select it. You will not lose any answers in the process.

- ○ » Bus
- ○ » Tram/Metro
- ○ » Train
- ○ » Car driver (private car)
- ○ » Car share (passenger or driver)
- ○ » Car passenger (private car)
- ○ » Walking
- ○ » Bicycle (private)
- ○ » Bicycle (bikesharing scheme/bike hire)
- ○ » Work provided Shuttle Bus
- ○ » Taxi/minicab
- ○ » Uber (on-demand ride services)
- ○ » Coach
- ○ » Park and Ride
- ○ » Motorcycle/moped

When travelling to work, do you normally use more than one form of transport within the same journey? (example taking the train first then catching the bus to work, exclude walking)

- ○ Yes
- ○ No
- ○ Don't know

Within an average week (Monday to Sunday), how many times do you travel to and from your workplace? (a return journey counts as 2)

From where you currently live, how long is your typical journey to work in terms of:

Journey duration to work (enter number in minutes)

Journey distance to work (enter number in miles)

From where you currently live, are public transport services available within walking distance?

- ○ Yes
- ○ No
- ○ Don't know

How often does the public transport service run from this stop?

- ○ Every few minutes
- ○ More than once an hour
- ○ Several times per day
- ○ Only a few times per day
- ○ Don't know

At your workplace, are public transport services available within walking distance?

- ○ Yes
- ○ No
- ○ Don't know

How often does the public transport service run from this stop?

- ○ Every few minutes
- ○ More than once an hour
- ○ Several times per day
- ○ Only a few times per day
- ○ Don't know

Travel behaviour for non-commuting activities

Which of the following non-commuting activities do you most often travel to within Birmingham? [choose only your most common activity]

- ○ Going shopping
- ○ Taking children to or back from school
- ○ Personal business (e.g. going to the bank, the doctors, etc.)
- ○ Leisure (visit friends at home and elsewhere, entertainment, sport, holiday and day trip)
- ○ Other

What is the main form of transport you normally use to travel to your non-commuting activity? If you use more than one means of transport, please choose the one with which you travel the longest distance.

- ○ Bus

- ○ Tram/Metro
- ○ Train
- ○ Car driver (private car)
- ○ Car share (passenger or driver)
- ○ Car passenger (private car)
- ○ Walking
- ○ Bicycle (private)
- ○ Bicycle (bikesharing scheme/bike hire)
- ○ University/Work Free Shuttle Bus
- ○ Taxi/minicab
- ○ Uber (on-demand ride services)
- ○ Coach
- ○ Park and Ride
- ○ Motorcycle/moped
- ○ Other

When travelling to your non-commuting activity, do you normally use more than one form of transport within the same journey ? (example taking the train first then catching the bus, exclude walking)

- ○ Yes
- ○ No
- ○ Don't know

Within an average week (Monday to Sunday), how many times do you travel to and from your non-commuting activity? (a return journey counts as 2)

From where you currently live, how long is your typical journey to your non-commuting activity in terms of:

Journey duration to non-commuting activity (enter number in minutes)

Journey distance to non-commuting activity (enter number in miles)

At your non-commuting activity, are public transport services available within walking distance?

- ○ Yes
- ○ No
- ○ Don't know

How often does the public transport service run from this stop?

- ○ Every few minutes
- ○ More than once an hour
- ○ Several times per day
- ○ Only a few times per day
- ○ Don't know

Mobility Tools

Which, if any, of the following forms of public transport passes, memberships or permit do you currently hold? Only include those that are valid for a week or longer. [choose all that apply]

- ☐ Bus pass
- ☐ Rail card
- ☐ Metro only pass
- ☐ Metro + bus pass
- ☐ Metro, bus and rail pass
- ☐ Coach membership
- ☐ Car club membership
- ☐ Bike share membership
- ☐ Swift card
- ☐ Parking permit
- ☐ Other
- ☐ None of the above

Do you hold a valid driving license to drive in the UK?

- ○ Yes
- ○ No
- ○ I'm learning to drive at the moment

Do you own a car or have access to someone else's car?

- ○ I own a car
- ○ I have access to someone else's car
- ○ I do not own and I do not have access to someone else's car

Do you own a bicycle or have access to someone else's bicycle?

- ○ I own a bicycle
- ○ I have access to someone else's bicycle
- ○ I do not own and I do not have access to someone else's bicycle

Do you use trip planner apps or websites to find information for your daily transport needs when travelling within Birmingham?

○ Yes
○ No
○ Don't know

Have you ever used your smartphone to purchase mobile travel tickets (mTickets)?

○ Yes
○ No
○ Don't know

Have a driving license and own a car

In this section you will be asked a series of questions relating to your opinion on using other means of transport instead of your private car. **Please keep in mind** that the following means of transport shall be collectively called 'shared mobility services and public transportation', these include:

Carsharing: provide members with access to fleets of vehicles on a pay-per-use basis (e.g. enterprise carclub/co-wheels carclub/Turo)

Ridesharing: when drivers of private vehicles pick up other passengers as part of a regular commute, or for specific journeys. Passengers pay the driver a fair price for the journey (e.g. Liftshare).

Bikesharing: short-term bicycle rental, payment is based on the number of minutes used

Public transportation: The bus, tram/metro and train services in Birmingham.

Given the availability of the following shared mobility services and public transportation, to what extent would you be willing to use these services for your everyday trips?

	Definitely will not use	Probably will not use	Might or might not use	Probably will use	Definitely will use
Carsharing	○	○	○	○	○
Ridesharing	○	○	○	○	○
Bikesharing	○	○	○	○	○
Public transportation	○	○	○	○	○

How much do you agree with the following statements?

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
I intend to use shared mobility services and public transportation instead of my private car for my everyday trips.	○	○	○	○	○
I will try to use shared mobility services and public transportation instead of my private car for my everyday trips.	○	○	○	○	○

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
I plan to use shared mobility services and public transportation instead of my private car for my everyday trips.	○	○	○	○	○

Use the following adjectives to continue the following sentence. Please read the adjectives carefully.

For me, using shared mobility services and public transportation, instead of my private car, for my everyday trips would be...

	1	2	3	4	5
pleasant (1)....unpleasant (5)	○	○	○	○	○
unsafe (1)....Very safe (5)	○	○	○	○	○
bad (overall experience) (1)....good (overall experience) (5)	○	○	○	○	○
expensive (1)....cheap (5)	○	○	○	○	○
convenient (1)....inconvenient (5)	○	○	○	○	○
relaxing (1)....stressful (5)	○	○	○	○	○
exciting (1)....boring (5)	○	○	○	○	○
harmful for the environment (1)....beneficial for the environment (5)	○	○	○	○	○
flexible (1)....inflexible (5)	○	○	○	○	○

How much do you agree with the following statements? Please read the statements carefully.

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
Most people who are important to me think that I should use shared mobility services and public transportation instead of my private car for my everyday trips.	○	○	○	○	○
Most people who are important to me use shared mobility services and public transportation instead of their private car for their everyday trips.	○	○	○	○	○
It is expected of me that I use shared mobility services and public transportation instead of my private car for my everyday trips.	○	○	○	○	○
Many people like me use shared mobility services and public transportation instead of their private car for their everyday trips.	○	○	○	○	○
The people in my life whose opinions I value would approve of me using shared mobility services and public transportation instead of my private car for my everyday trips.	○	○	○	○	○
The people in my life whose opinions I value, use shared mobility services and public transportation instead of their private car for their everyday trips.	○	○	○	○	○

How much do you agree with the following statements?

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
I am confident that I could use shared mobility services and public transportation instead of my private car for my everyday trips if I wanted to.	○	○	○	○	○
For me to use shared mobility services and public transportation instead of my private car for my everyday trips is easy.	○	○	○	○	○

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
The decision to use shared mobility services and public transportation instead of my private car for my everyday trips is beyond my control.	○	○	○	○	○
Whether or not I use shared mobility services and public transportation instead of my private car for my everyday trips is entirely up to me.	○	○	○	○	○

Socio-demographics Student

These last few questions are to help us understand your current circumstances.

In what year were you born (YYYY)?

Are you...?

- Male
- Female
- Other
- Prefer not to say

Where do you live? Enter your postcode district (example B6)

Which of the following best describes your student status?

- Full-time Student only
- Full-time student with a part-time job at university
- Full-time student with a part-time job outside university
- Other

What type of degree are you studying for?

- Undergraduate
- Postgraduate (Masters)
- PhD
- Other

Which University do you go to?

- University of Birmingham
- Birmingham City University
- Aston University
- Newman University
- Other

Which of the following types of residence do you reside in?

- Parental/guardian home
- Owned residence
- University owned/Private sector halls/rented property
- Other

Do you have any long-term physical or health issues that limits your ability to travel?

- Yes
- No
- Prefer not to answer
- Don't know

Are you in your final year of studies?

- Yes
- No

Socio-demographic Graduate

These last few questions are to help us understand your current circumstances.

In what year were you born (YYYY)?

Are you...?

- Male
- Female
- Other
- Prefer not to say

Where do you live? Enter your postcode district (example B6)

What is the highest level of education you have completed?

- GCSE or O-Level
- A-Level (highschool diploma)
- Bachelor Degree
- Masters Degree
- Doctoral or Professional Degree
- Vocational Qualifications
- None of the above

Are you a staff member at the university?

- Yes
- No
- Prefer not to say

Which University do you work for?

- University of Birmingham
- Birmingham City University
- Aston University
- Newman University
- Other

What is your employment status?

- Working full-time
- Working part-time
- Employed full-time and self-employed part-time
- Working full-time - self employed
- Working part-time - self employed
- Other

Which of the following types of residence do you reside in?

- Parental/guardian home
- Owned residence
- Rented property
- Other

Do you have any long-term physical or health issues that limits your ability to travel?

- Yes
- No
- Prefer not to answer
- Don't know

End of Survey + Mobility-as-a-Service

Thank you!

We very much appreciate your help with our research project. However before you leave, you can increase your chances of winning if you can spare a few minutes to answer the following questions about a new digital transport service for Birmingham.

Would you like to take this survey?

- Yes
- No

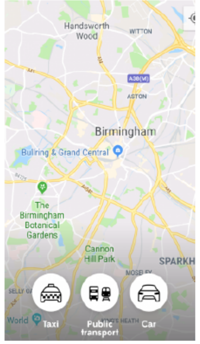
Here we will introduce you to a new digital transport service called 'mobility as a service'

Mobility-as-a-Service is a term used to describe digital transport platforms from which people can access a range of public, shared and private transport, using a system (either an app or website) that integrates the planning, booking and paying for travel.

This service works similarly to a journey planner such as Google Maps and Citymapper but with an added payment system through the app and the option to choose from a variety of transport modes available in your area.

The payment system works similarly to a mobile subscription where you can either pay a fixed price for a bundle of different transport services or pay for every ride you make (pay-as-you-go).

As an example, this is a screenshot taken from the Whim app allowing you to choose different transport modes for your journey. This includes public transport services, taxis and car rentals in Birmingham. Other transport services that can be available are carsharing, ridesharing and bikesharing services.



Having read what mobility-as-a-service is about, answer the following questions.

Mobility-as-a-service combines all transport modes from different transport operators into one user account.

- ○ Yes
- ○ No
- ○ Don't know

Mobility-as-a-service allows me to use car sharing facilities if I wanted to.

- ○ Yes
- ○ No
- ○ Don't know

Mobility-as-a-service works similarly to a mobile subscription where I can pay a fixed price for a bundle of services or otherwise pay for every ride I make (pay-as-you-go).

- ○ Yes
- ○ No
- ○ Don't know

Have you ever used mobility-as-a-service? Example the Whim app.

- ○ No - I have never heard of this
- ○ No - but I have heard of this
- ○ Yes - in the past but not currently
- ○ Yes - currently

How confident do you think you are using mobility-as-a-service to plan and pay for your everyday travels during an average day?

- ○ Extremely confident
- ○ Very confident
- ○ Moderately confident
- ○ Slightly confident
- ○ Not at all confident

How likely are you to try a mobility-as-a-service app before deciding to commit to it or not?

- ○ Extremely likely
- ○ Somewhat likely
- ○ Neither likely nor unlikely
- ○ Somewhat unlikely
- ○ Extremely unlikely

You have completed this survey!

We very much appreciate your time in taking this survey. If you're interested, you can find further details about the project here: www.silci.org

To enter the chance to win one of five Amazon Gift cards (£50, £40, £30, £20, £10), please provide us with a suitable contact email address and/or number. Winners will be notified by email and/or text message. Best of Luck!

- ☐ Email address
- ☐ Mobile phone number

Appendix B

Intro Screen

Welcome to this Travel Behaviour Survey!

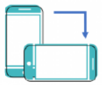
Thank you for choosing to take part in our study.

This survey will ask you how you travel to your place of work or study using a choice experiment, and takes approximately 15 minutes to complete.

All data collected in the study will be held anonymously and securely and will only be accessed by the research team at the University of East Anglia.

This study has gained ethical approval from the General Research Ethics Committee at the University of East Anglia, Norwich, UK.

If you are taking this survey on a mobile device, we advise you to turn on your auto-rotate screen function before starting the survey.



You can choose to stop participating at any time by closing the web browser.

By clicking 'Yes' to take the survey, I consent to participate in the survey and for my data to be used for its stated purpose.

- Yes
- No

In which country do you currently reside?

Which UK region do you reside in?

How old are you?

Which of the following best describes your status?

- Full-time student attending a higher education institution in the West Midlands
- Employed or Self-employed with place of work located in the West Midlands
- Full-time student, Employed or Self-Employed outside of the West Midlands

COVID-19 questions Worker

To start, we will ask you about your employment status and travel behaviour **during** the travel restrictions and lockdown measures that started in March 2020.

How has your commute changed soon after travel restrictions and lockdown measures started in March 2020?

- I continue to commute to work
- I have recently been furloughed or laid off
- Used to commute (before travel restrictions and lockdown measures started), now work from home
- Used to work from home (before travel restrictions and lockdown measures started) and still do
- Used to work from home (before travel restrictions and lockdown measures started) but now I commute
- None of the above (please specify)

How are you currently travelling to your place of work?

- Walking
- Cycling
- Driving
- Passenger in private car
- Public Transport
- Other

How do you plan to travel to your place of work once the Government removes travel restrictions?

[ ]

Filter question - Workers

We are now going to ask you some questions about your work situation **BEFORE** travel restrictions and lockdown measures started in March 2020.

Before travel restrictions and lockdown measures started in March 2020, did you travel to your place of work by car, public transport, cycle or other type of motorised transport (taxi, scooter, moped, e-bike)?

- ○ Yes
- ○ No

Do you hold any of these types of driving licence? Please check all that apply if licence is current and valid in the UK.

- ☐ Full licence - car
- ☐ Full licence - motorcycle or moped
- ☐ Provisional licence - car
- ☐ Provisional licence - motorcycle or moped
- ☐ None of the above

COVID-19 questions Student

To start, we will ask you about your student status and travel behaviour **during** the travel restrictions and lockdown measures that started in March 2020.

Have you travelled to your place of study between April and May 2020?

- ○ Yes
- ○ No

How did you travel to your place of study between April and May 2020?

- ○ Walking
- ○ Cycling
- ○ Driving
- ○ Car Passenger in private car
- ○ Public transport
- ○ [ ] Other

If you are returning to your educational institution in September 2020, how do you plan to travel to your place of study?

[ ]

Filter question - Student

We are now going to ask you some questions about your study situation **BEFORE** travel restrictions and lockdown measures started in March 2020.

Before travel restrictions and lockdown measures started in March 2020, did you travel to your place of study by car, public transport, cycle or other type of motorised transport (taxi, scooter, moped, e-bike)?

- ○ Yes
- ○ No

Do you hold any of these types of driving licence? Please check all that apply if licence is current and valid in the UK.

- ☐ Full licence - car
- ☐ Full licence - motorcycle or moped
- ☐ Provisional licence - car
- ☐ Provisional licence - motorcycle or moped
- ☐ None of the above

Shopping, Leisure and Recreational Activity

We are now going to ask you some questions about your **trips to activities such as shopping, leisure and recreational activities** within the West Midlands **BEFORE** travel restrictions and lockdown measures started in March 2020.

In this survey, we use "**trip**" to describe an individual going from origin to destination for a specific purpose using a specific means of transport.

A trip refers to a one way journey and a return trip is counted as two separate journeys.

Thinking about your **trips to shopping, leisure and recreational activities** within the West Midlands, which of the following means of transport did you use **in a typical week**? Please select all that apply.

We know that the recent travel restrictions and lockdown measures might have influenced the way you travel to your shopping, leisure and recreational activities, so please try to think about your typical behaviour ***before March 2020***.

- ☐ Bus
- ☐ Tram
- ☐ Train
- ☐ Car or Van driver (private car)
- ☐ Car or Van passenger (private car)
- ☐ Car share or Ride share (passenger or driver using car rental or car club or liftshare services)
- ☐ Walking (journey on foot of 5 minutes or more)
- ☐ Bicycle (private)
- ☐ Bicycle (public bicycle sharing system or bicycle hire)
- ☐ Electric bicycle
- ☐ Taxi or minicab
- ☐ Uber
- ☐ Coach
- ☐ Motorcycle, moped or scooter

Please enter **how many trips per week** were taken with the following means of transport.

Please count travelling to and from your place of shopping, leisure and recreational activity as two separate trips.

We know that the recent travel restrictions and lockdown measures might have influenced how often you take trips to your shopping, leisure and recreational activities, so please try to think about your typical behaviour ***before March 2020***.

	Number of trips per week
» Bus	☐
» Tram	☐
» Train	☐
» Car or Van driver (private car)	☐
» Car or Van passenger (private car)	☐
» Car share or Ride share (passenger or driver using car rental or car club or liftshare services)	☐
» Walking (journey on foot of 5 minutes or more)	☐
» Bicycle (private)	☐
» Bicycle (public bicycle sharing system or bicycle hire)	☐
» Electric bicycle	☐
» Taxi or minicab	☐
» Uber	☐
» Coach	☐

Number of trips per week

» Motorcycle, moped or scooter ☐

Do you combine two or more of the above listed means of transport in one trip? (exclude walking)

[⌄]

How long (approximately) would it take you to walk from your **house** to the nearest...

...Bus Stop	...Rail Station	...Tram Stop
⌄	⌄	⌄

Worker Travel

We are now going to ask you some questions about your **trips to your place of work** within the West Midlands **BEFORE** travel restrictions and lockdown measures started in March 2020.

In this survey, we use "**trip**" to describe an individual going from origin to destination for a specific purpose using a specific means of transport.

A trip refers to a one way journey and a return trip is counted as two separate journeys.

Thinking about your **trips to your place of work** within the West Midlands, which of the following means of transport did you use **in a typical week**? Please select all that apply.

We know that the recent travel restrictions and lockdown measures might have influenced the way you travel to your place of work, so please try to think about your typical behaviour ***before March 2020****.*

- ☐ Bus
- ☐ Bicycle (public bicycle sharing system or bicycle hire)
- ☐ Tram
- ☐ Electric bicycle
- ☐ Train
- ☐ Shuttle Bus provided by place of work or study
- ☐ Car or Van driver (private car)
- ☐ Taxi or minicab
- ☐ Car or Van passenger (private car)
- ☐ Uber
- ☐ Car share or Ride share (passenger or driver using car rental, car club or liftshare services)
- ☐ Coach
- ☐ Bicycle (private)
- ☐ Motorcycle, moped or scooter

Please enter **how many trips per week** were taken with the following means of transport.

Please count travelling to and from your place of work as two separate trips.

We know that the recent travel restrictions and lockdown measures might have influenced how often you take trips to your place of work, so please try to think about your typical behaviour ***before March 2020****.*

	Number of trips per week
» Bus	☐
» Tram	☐
» Train	☐
» Car or Van driver (private car)	☐
» Car or Van passenger (private car)	☐
» Car share or Ride share (passenger or driver using car rental, car club or liftshare services)	☐
» Bicycle (private)	☐
» Bicycle (public bicycle sharing system or bicycle hire)	☐
» Electric bicycle	☐
» Shuttle Bus provided by place of work or study	☐
» Taxi or minicab	☐
» Uber	☐
» Coach	☐
» Motorcycle, moped or scooter	☐

Do you combine two or more of the above listed means of transport when travelling to your place of work in one trip?

We are interested in your typical daily travel pattern, whether you travel directly from your home to work and then back home, or take other trips when going to work or travelling back home from work.

Which of the following statements best describe your typical daily travel pattern to or from your place of work **excluding** trips taken by walk.

- I travel directly from home to work and then back home
- I take trips to other places between home and work or when going back home from work
- Prefer not to say
- Don't know

On a typical day, how long is your trip time from home to your place of work, one way?

How far is your place of work from home?

How long (approximately) would it take you to walk from your **place of work** to the nearest...

...Bus Stop	...Rail Station	...Tram Stop

Student Travel

We are now going to ask you some questions about your **trips to your place of study** within the West Midlands **BEFORE** travel restrictions and lockdown measures started in March 2020.

In this survey, we use "**trip**" to describe an individual going from origin to destination for a specific purpose using a specific means of transport.

A trip refers to a one way journey and a return trip is counted as two separate journeys.

Thinking about your **trips to your place of study** within the West Midlands, which of the following means of transport did you use in **a typical week**? Please select all that apply.

*We know that the recent travel restrictions and lockdown measures might have influenced the way you travel to your place of study, so please try to think about your typical behaviour **before March 2020**.*

- Bus
- Tram
- Train
- Car or Van driver (private car)
- Car or Van passenger (private car)
- Car share or Ride share (passenger or driver using car rental, car club or liftshare services)
- Bicycle (private)
- Bicycle (public bicycle sharing system or bicycle hire)
- Electric bicycle
- Shuttle Bus provided by place of work or study
- Taxi or minicab
- Uber
- Coach
- Motorcycle, moped or scooter

Please enter **how many trips to your place of study per week** were taken with the following means of transport.

Please count travelling to and from your place of study as two separate trips.

*We know that the recent travel restrictions and lockdown measures might have influenced how often you take trips to your place of study, so please try to think about your typical behaviour **before March 2020**.*

	Number of trips per week
» Bus	
» Tram	
» Train	
» Car or Van driver (private car)	
» Car or Van passenger (private car)	

	Number of trips per week
» Car share or Ride share (passenger or driver using car rental, car club or liftshare services)	
» Bicycle (private)	
» Bicycle (public bicycle sharing system or bicycle hire)	
» Electric bicycle	
» Shuttle Bus provided by place of work or study	
» Taxi or minicab	
» Uber	
» Coach	
» Motorcycle, moped or scooter	

Do you combine two or more of the above listed means of transport when travelling to your place of study, in one trip? (exclude walking)

We are interested in your typical daily travel pattern, whether you travel directly from your home to your place of study and then back home, or take other trips when going to your place of study or travelling back home from your place of study.

Which of the following statements best describe your typical daily travel pattern to or from your place of study **excluding** trips taken by walk.

- I travel directly from home to my place of study and then back home
- I take trips to other places between home and my place of study or when going from my place of study back home
- Prefer not to say
- Don't know

On a typical day, how long is your trip time from home to your place of study, one way?

How far is your place of study from home?

How long (approximately) would it take you to walk from your **place of study** to the nearest...

...Bus Stop	...Rail Station	...Tram Stop

Mobility Tools

Do you own or have access to any of the following vehicles?

Car

Van

Bicycle or Electric bicycle

Motorcycle, moped or scooter

How often is the car available to you?

- Always
- Frequently
- Rarely / upon prior agreement
- Other, please specify

How often is the van available to you?

- Always
- Frequently
- Rarely or upon prior agreement
- Other, please specify

Which, if any, of the following forms of public transport passes, memberships or permit do you currently hold? Only include those that are valid for a month or longer. [choose all that apply]

- Swift photocard - Bus only pass
- Rail only pass (not swift photocard)

- [ ] Swift photocard - Rail only pass
- [ ] Swift photocard - Metro only pass
- [ ] Swift on mobile - Metro only pass
- [ ] Swift photocard - bus and train pass
- [ ] Swift photocard - bus and tram pass
- [ ] Swift photocard - bus, tram and train pass
- [ ] My Metro app - Metro pass
- [ ] Bus only pass (not swift photocard)
- [ ] National Railcard - Discount Card
- [ ] Coach membership
- [ ] Car club membership
- [ ] Bicycle share membership
- [ ] Parking permit issued by the place of work or study
- [ ] Other, please specify ______
- [ ] None of these

Do you use your smartphone to find information for your travel needs? Example route planning, booking, paying for tickets, navigation etc.

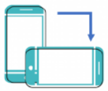
[▾]

For which of the following do you typically use your smartphone? Please choose all that apply.

- [ ] Route planning or route planning apps
- [ ] Maps, navigation or satnavs
- [ ] Checking live travel times (e..g bus, train, tram, fights etc.)
- [ ] Buying train, bus or other public transport tickets online
- [ ] Checking traffic updates
- [ ] Booking a taxi or minicab using Uber
- [ ] Booking a taxi or minicab using another app (not Uber)
- [ ] Paying for taxi services online
- [ ] Finding out about services available in the area (e.g. restaurants, cafes, shops, garages)
- [ ] Other ______

Randomized Choice Card example

If you are using a mobile device, for this section we strongly advise to rotate your mobile device horizontally for better viewing.



We are now going to ask you to choose a monthly travel plan from four available monthly plans.

When making your choice we ask you to imagine that you need to travel to your place of work or study in Birmingham City centre for 3 to 5 days a week.

Your travel distance is 7 miles from your home to your place of work or study.

Links to transport maps are available in the table to show which zones are covered by bus, train and tram services. Please click on the titles in the top row of each column to open the links.

Each choice will be described using a **choice card**, an **example** of which is shown below.

Assume you live 7 miles away from Birmingham City centre.

You need to commute to your place of work or study into Birmingham City centre 3 to 5 days a week.

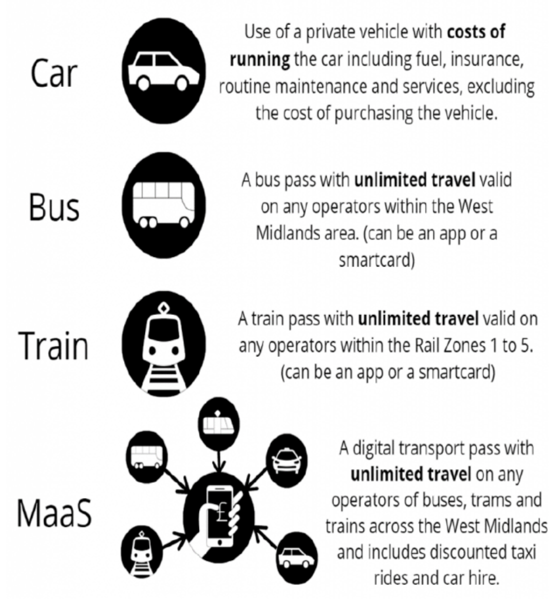
Please choose the monthly travel plan you would prefer, keeping in mind any money spent on travel cannot be spent elsewhere.

Alternatives / Attributes	Car - Use of a private car	Bus - Anytime and unlimited use across the West Midlands	Train - Anytime and unlimited use within the specified Rail Zones 1 to 5	MaaS - Anytime and unlimited use of bus, tram, train within zones 1 to 5, and discounted taxi and car hire
Monthly Cost **Car** - cost of running a car (not including the cost of the car itself) **Bus, Train, or MaaS**: Cost of monthly subscription	£162	£70	£60	£110
In Vehicle Time (minutes) per commute trip Average time taken inside a means of transport	20	40	35	35
Walking Time (minutes) per commute trip Average time taken to walk to a public transport stop or to the car	9	8	6	6

Alternatives / Attributes	**Car -** Use of a private car	**Bus -** Anytime and unlimited use across the West Midlands	**Train -** Anytime and unlimited use within the specified Rail Zones 1 to 5	**MaaS -** Anytime and unlimited use of bus, tram, train within zones 1 to 5, and discounted taxi and car hire
Waiting Time (minutes) per commute trip Average time taken from the instant you arrive at a stop or station and wait until the next scheduled departure	0	9	9	6

MaaS introduction

You will be shown eight of these **choice cards**, each one describes four different monthly travel plan options as shown below.

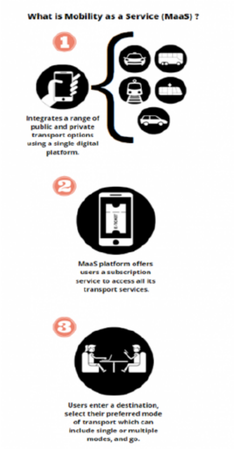


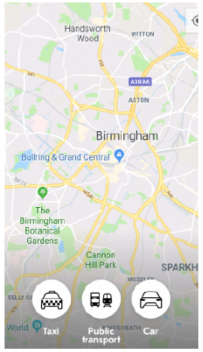
We understand that the concept of MaaS is relatively new and so below we provide a description of the service and how it works.

Description
MaaS (Mobility as a Service) is a digital platform (either an app or website) which enables you to access and pay for a range of public and private transport options from different transport operators. You pay for a monthly package which would be tailored to you, such as paying for unlimited public transport options and two taxis a month. The app would also make recommendations on which travel options might be best for you using real time information, such as on traffic levels.

How payment works
The payment system works similarly to a mobile phone subscription where for a mobile subscription you buy a bundle of unlimited data, text and calls for a monthly fee. For MaaS you pay a monthly fee using a debit or credit card to cover transport costs by purchasing a bundle of unlimited bus, train and tram trips with access to discounted taxi services and car rental companies in the West Midlands.

The following infographic explains what MaaS is, and the mobile screenshot taken from the app 'Whim' by MaaS Global, gives an example of how a MaaS app looks like on a smartphone.





Which of the following statements are true about MaaS?

	True	False
1. A monthly MaaS plan includes discounted taxi and car hire services.	O	O
2. A monthly plan includes unlimited use of bus, train and tram within the West Midlands.	O	O
3. You can use a monthly MaaS plan on bus services only.	O	O
4. You can travel anytime and anywhere within the West Midlands	O	O

Information to read prior taking choice experiment

Before continuing to your **eight choice tasks** we would like to share with you the following:

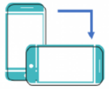
Experiences from other studies have shown that people tend to respond differently to hypothetical situations than they would in real life situations. This is most likely because they don't actually have to follow through with their choices in hypothetical situations.

Although the scenario used in this study is hypothetical, the monthly cost, travel times, waiting times and walking times are actual measurements.

When making your choice, please be mindful of the features presented as well as the means of transport being offered.

Links to transport maps are available in the table to show which zones are covered by bus, train and tram services. Please click on the titles in the top row of each column to open the links.

If you are using a mobile device, we strongly advise to rotate your mobile device horizontally for better viewing of the choice cards.



O I have read the above information

Block1

Assume you live 7 miles away from Birmingham City centre.

You need to commute to your place of work or study into Birmingham City centre 3 to 5 days a week.

Please choose the monthly travel plan you would prefer, keeping in mind any money spent on travel cannot be spent elsewhere.

Alternatives / Attributes	Car - Use of a private car	Bus - Anytime and unlimited use across the West Midlands	Train - Anytime and unlimited use within the specified Rail Zones 1 to 5	MaaS - Anytime and unlimited use of bus, tram, train within zones 1 to 5, and discounted taxi and car hire

Alternatives / Attributes	Car - Use of a private car	Bus - Anytime and unlimited use across the West Midlands	Train - Anytime and unlimited use within the specified Rail Zones 1 to 5	MaaS - Anytime and unlimited use of bus, tram, train within zones 1 to 5 and discounted taxi and car hire
Monthly Cost **Car** - cost of running a car (not including the cost of the car itself) **Bus, Train, or MaaS**: Cost of monthly subscription	£130	£51	£82	£100
In Vehicle Time (minutes) per commute trip Average time taken inside a means of transport	35	30	25	25
Walking Time (minutes) per commute trip Average time taken to walk to a public transport stop or to the car	0	10	12	12
Waiting Time (minutes) per commute trip Average time taken from the instant you arrive at a stop or station and wait until the next scheduled departure	0	3	9	9

Your choice: Car ○ Bus ○ Train ○ MaaS ○

Assume you live 7 miles away from Birmingham City centre.

You need to commute to your place of work or study into Birmingham City centre 3 to 5 days a week.

Please choose the monthly travel plan you would prefer, keeping in mind any money spent on travel cannot be spent elsewhere.

Alternatives / Attributes	Car - Use of a private car	Bus - Anytime and unlimited use across the West Midlands	Train - Anytime and unlimited use within the specified Rail Zones 1 to 5	MaaS - Anytime and unlimited use of bus, tram, train within zones 1 to 5 and discounted taxi and car hire
Monthly Cost **Car** - cost of running a car (not including the cost of the car itself) **Bus, Train, or MaaS**: Cost of monthly subscription	£162	£70	£60	£110
In Vehicle Time (minutes) per commute trip Average time taken inside a means of transport	20	40	35	35
Walking Time (minutes) per commute trip Average time taken to walk to a public transport stop or to the car	9	8	6	6
Waiting Time (minutes) per commute trip Average time taken from the instant you arrive at a stop or station and wait until the next scheduled departure	0	9	9	6

Your choice: Car ○ Bus ○ Train ○ MaaS ○

Assume you live 7 miles away from Birmingham City centre.

You need to commute to your place of work or study into Birmingham City centre 3 to 5 days a week.

Please choose the monthly travel plan you would prefer, keeping in mind any money spent on travel cannot be spent elsewhere.

Alternatives / Attributes	Car - Use of a private car	Bus - Anytime and unlimited use across the West Midlands	Train - Anytime and unlimited use within the specified Rail Zones 1 to 5	MaaS - Anytime and unlimited use of bus, tram, train within zones 1 to 5, and discounted taxi and car hire
Monthly Cost **Car** - cost of running a car (not including the cost of the car itself) **Bus, Train, or MaaS**: Cost of monthly subscription	£130	£51	£82	£110
In Vehicle Time (minutes) per commute trip Average time taken inside a means of transport	35	30	30	30
Walking Time (minutes) per commute trip Average time taken to walk to a public transport stop or to the car	0	10	9	9
Waiting Time (minutes) per commute trip Average time taken from the instant you arrive at a stop or station and wait until the next scheduled departure	0	3	12	6

	Car	Bus	Train	MaaS
Your choice:	○	○	○	○

Assume you live 7 miles away from Birmingham City centre.

You need to commute to your place of work or study into Birmingham City centre 3 to 5 days a week.

Please choose the monthly travel plan you would prefer, keeping in mind any money spent on travel cannot be spent elsewhere.

Alternatives / Attributes	Car - Use of a private car	Bus - Anytime and unlimited use across the West Midlands	Train - Anytime and unlimited use within the specified Rail Zones 1 to 5	MaaS - Anytime and unlimited use of bus, tram, train within zones 1 to 5, and discounted taxi and car hire
Monthly Cost **Car** - cost of running a car (not including the cost of the car itself) **Bus, Train, or MaaS**: Cost of monthly subscription	£162	£51	£75	£90
In Vehicle Time (minutes) per commute trip Average time taken inside a means of transport	25	45	25	25
Walking Time (minutes) per commute trip Average time taken to walk to a public transport stop or to the car	6	4	12	12
Waiting Time (minutes) per commute trip Average time taken from the instant you arrive at a stop or station and wait until the next scheduled departure	0	3	12	9

	Car	Bus	Train	MaaS
Your choice:	○	○	○	○

Assume you live 7 miles away from Birmingham City centre.

You need to commute to your place of work or study into Birmingham City centre 3 to 5 days a week.

Please choose the monthly travel plan you would prefer, keeping in mind any money spent on travel cannot be spent elsewhere.

Alternatives / Attributes	Car - Use of a private car	Bus - Anytime and unlimited use across the West Midlands	Train - Anytime and unlimited use within the specified Rail Zones 1 to 5	MaaS - Anytime and unlimited use of bus, tram, train within zones 1 to 5, and discounted taxi and car hire
Monthly Cost **Car** - cost of running a car (not including the cost of the car itself) **Bus, Train, or MaaS**: Cost of monthly subscription	£178	£70	£67	£80
In Vehicle Time (minutes) per commute trip Average time taken inside a means of transport	25	40	35	35
Walking Time (minutes) per commute trip Average time taken to walk to a public transport stop or to the car	6	8	6	6
Waiting Time (minutes) per commute trip Average time taken from the instant you arrive at a stop or station and wait until the next scheduled departure	0	9	3	0

	Car	Bus	Train	MaaS
Your choice:	O	O	O	O

Assume you live 7 miles away from Birmingham City centre.

You need to commute to your place of work or study into Birmingham City centre 3 to 5 days a week.

Please choose the monthly travel plan you would prefer, keeping in mind any money spent on travel cannot be spent elsewhere.

Alternatives / Attributes	Car - Use of a private car	Bus - Anytime and unlimited use across the West Midlands	Train - Anytime and unlimited use within the specified Rail Zones 1 to 5	MaaS - Anytime and unlimited use of bus, tram, train within zones 1 to 5, and discounted taxi and car hire
Monthly Cost **Car** - cost of running a car (not including the cost of the car itself) **Bus, Train, or MaaS**: Cost of monthly subscription	£145	£64	£75	£80
In Vehicle Time (minutes) per commute trip Average time taken inside a means of transport	30	40	20	20
Walking Time (minutes) per commute trip Average time taken to walk to a public transport stop or to the car	3	6	15	15
Waiting Time (minutes) per commute trip Average time taken from the instant you arrive at a stop or station and wait until the next scheduled departure	0	9	6	3

	Car	Bus	Train	MaaS
Your choice:	O	O	O	O

Assume you live 7 miles away from Birmingham City centre.

You need to commute to your place of work or study into Birmingham City centre 3 to 5 days a week.

Please choose the monthly travel plan you would prefer, keeping in mind any money spent on travel cannot be spent elsewhere.

Alternatives / Attributes	Car - Use of a private car	Bus - Anytime and unlimited use across the West Midlands	Train - Anytime and unlimited use within the specified Rail Zones 1 to 5	MaaS - Anytime and unlimited use of bus, tram, train within zones 1 to 5, and discounted taxi and car hire
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In Vehicle Time (minutes) per commute trip Average time taken inside a means of transport	20	40	35	35
Walking Time (minutes) per commute trip Average time taken to walk to a public transport stop or to the car	9	10	6	6
Waiting Time (minutes) per commute trip Average time taken from the instant you arrive at a stop or station and wait until the next scheduled departure	0	6	12	9

	Car	Bus	Train	MaaS
Your choice:	O	O	O	O

Assume you live 7 miles away from Birmingham City centre.

You need to commute to your place of work or study into Birmingham City centre 3 to 5 days a week.

Please choose the monthly travel plan you would prefer, keeping in mind any money spent on travel cannot be spent elsewhere.

Alternatives / Attributes	Car - Use of a private car	Bus - Anytime and unlimited use across the West Midlands	Train - Anytime and unlimited use within the specified Rail Zones 1 to 5	MaaS - Anytime and unlimited use of bus, tram, train within zones 1 to 5, and discounted taxi and car hire
Monthly Cost **Car** - cost of running a car (not including the cost of the car itself) **Bus, Train, or MaaS**: Cost of monthly subscription	£145	£57	£67	£110
In Vehicle Time (minutes) per commute trip Average time taken inside a means of transport	30	35	20	20
Walking Time (minutes) per commute trip Average time taken to walk to a public transport stop or to the car	3	4	15	15
Waiting Time (minutes) per commute trip Average time taken from the instant you arrive at a stop or station and wait until the next scheduled departure	0	12	3	3

	Car	Bus	Train	MaaS
Your choice:	O	O	O	O

Attribute Non-Attendance Questions

In the choices that you have just made on your travel preferences for a given month on travelling to your place of work or study, how often did you consider each of the following individual trip characteristics when making your choice?

	Always Considered	Sometimes Considered	Never Considered
Monthly Cost (£)	O	O	O
In-vehicle time (minutes)	O	O	O
Walking time (minutes)	O	O	O
Waiting time (minutes)	O	O	O

Keywords related to MaaS & likeliness of reducing car use

How likely, if at all, would you consider a MaaS subscription, if a bikesharing membership for unlimited use of bicycle trips is included together with access to public transport and discounted taxi service?

To better understand the reasons and needs that would motivate you to use MaaS, please specify what characteristics need to be included in a MaaS monthly plan to make it appealing for you to use as a monthly subscription plan to travel to your place of work or study.

How likely, if at all, would you reduce your car or van use if you knew MaaS was available?

Please explain what you mean by 'it depends'

And how likely, if at all, would you be to give up ownership of your car or van if you knew MaaS was available?

Please explain what you mean by 'it depends'

Sociodemographic questions - Worker

The following questions are about yourself and your household.

Are you...?

- Male
- Female
- Other
- Prefer not to say

Where do you live? Enter the first 4 digits of your postcode district (for example WV98)

Is your place of work located in Birmingham?

- Yes
- No
- Prefer not to say
- Don't know

Is your place of work located in the centre of Birmingham (within the A4540 main ring road)?

- Yes
- No
- Prefer not to say
- Don't know

Before the travel restrictions and lockdown measures were put in place in March 2020, what was your employment status?

- Full-time paid employment (30+ hours a week)
- Part-time paid employment (less than 30 hours a week)
- Full-time self-employment (30+ hours a week)
- Part-time self-employment (less than 30 hours a week)
- Both employed and self-employed
- Other

Which of the following best describes your working schedule?

- I have some flexibility in when I leave the work place but not when I arrive
- I have very set working hours
- I have some flexibility in when I arrive to the work place but not when I leave
- I have complete flexibility in when I arrive and leave
- ________ Other - please specify

What is the highest level of education you have completed?

- No formal qualification
- GCSE or equivalent
- A levels
- Vocational qualifications (such as an apprenticeship)
- Undergraduate Degree
- Postgraduate Degree
- PhD
- Other school qualifications

Which of the following types of residence do you reside in?

- Parental or guardian home
- Owned home
- Rented property
- ________ Other

Including yourself, how many people (adults and children) live in your household?

[▾]

Who else lives in your household? (Please check all that apply)

- [ ] Spouse or Partner
- [ ] Parent(s) or parent(s)-in-law
- [ ] Child(ren) 15 years or under
- [ ] Child(ren) over 15 years
- [ ] Other relative
- [ ] Other non-relative or roommate or housemate
- [ ] Prefer not to answer

How many cars are available to you in your household?

[▾]

We would now like to ask you about your total household income (before tax).

Please note this will be used only for statistical purposes and treated with strict confidentiality.

- less than £15,000
- £15,000 - £19,999
- £20,000 - £24,999
- £25,000 - £29,999
- £30,000 - £34,999
- £35,000 - £39,999
- £40,000 - £44,999
- £45,000 - £54,999
- £55,000 or more
- Prefer not to say
- Don't know

Do you have any long-term physical or health issue that limits your ability to travel?

- Yes
- No
- Prefer not to answer

Sociodemographic questions - Student

The following questions are about yourself and your household.

Are you...?

- Male
- Female
- Other
- Prefer not to say

Where do you live? Enter the first 4 digits of your postcode district (for example WV98)

Which University do you go to?

What type of degree are you studying?

- HND/foundation
- Undergraduate
- PGCE
- Postgraduate
- PhD
- Other

Which of the following types of residence do you reside in?

- Parental or guardian home
- Owned home
- University owned, private sector or rented property
- Other

Including yourself, how many people (adults and children) live in your household?

Who else lives in your household? (Please check all that apply)

- Spouse/Partner
- Parent(s) or parent(s)-in-law
- Child(ren) 15 years or under
- Child(ren) over 15 years
- Other relative
- Other non-relative or roommate or housemate
- Prefer not to answer

How many cars are available to you in your household?

We would now like to ask you about your total household income (before tax).

Please note this will be used only for statistical purposes and treated strictly confidentially.

- less than £15,000
- £15,000 - £19,999
- £20,000 - £24,999
- £25,000 - £29,999
- £30,000 - £34,999
- £35,000 - £39,999
- £40,000 - £44,999
- £45,000 - £54,999
- £55,000 or more
- Prefer not to say
- Don't know

Do you have any long-term physical or health issue that limits your ability to travel?

- Yes
- No
- Prefer not to answer

End of Block

Thank you for completing our survey!

We very much appreciate your time in taking this survey. If you're interested, you can find further details about the project here: www.silci.org

Progress Bar

Powered by Qualtrics

Appendix C

Opening
Thank you for taking the time and accepting our invitation to be part of our research study.

My name is Emma and I will be asking you questions related to your travel behaviour. This is part of my PhD research and the results from this interview will help in understanding how young adults commute and travel.

There are no right, or wrong answers and your opinions and comments are extremely valuable for this research. Just to remind you that all responses will be kept confidential and any information used will be anonymised.

Before I start to record the session, are there any questions?

Start Recorder

Topic/ Question	**Follow up questions**	**Reasons for asking**
Aim to understand commute travel as a student and as an employee.		
University Commute		
How would you describe your commute to university and what was your experience?	Mode of travel	Previous and Current transport modes to identify change in transport modes
	Time of commute/ Distance of commute	Previous and Current commute distance to identify change in distances
What was your experience using {transport mode}?	Positive, negative, Why, Why not?	Identify attitudes and subjective preferences
What types of transport modes did you have available where you live?	How accessible where they? What was your experience?	Identify accessibility to other transport modes - enablers and barriers - if they did use other transport modes then what was their experience and what was the reason for them to change their transport mode. If they did not use other transport modes then identify factors which makes the participant why not to use other transport modes (inconvenience, comfort, access?)
Was there a time when you had to change your commute to university?	Because of an event or had to carry something into university?	
Did you try using other transport modes such as carsharing, bike sharing?	What was you experience? / Why not?	

Topic/ Question	**Follow up questions**	**Reasons for asking**
In the survey you said **you have** a driving licence; can you tell me when you got your driving licence and what made you decide to get a driving licence?		Motivation to get a driving licence and the opportunities available to follow up and get a licence
In the survey you said **you do not have** a driving licence, can you tell me what would make you decide to get a driving licence?		Which factors would prompt participant to get a driving licence?
Work Commute		
In the survey you said you commute by *** and it takes you *** is this correct?	How often do/did you commute to work?	Previous and Current transport modes to identify change in transport modes
How easy or difficult would it be for you to reduce your commute by car?	Would you go as far as to avoid public transport to commute?	Willingness not to use public transport
	How would you describe your experience commuting to work by car?	Attitudes and subjective preferences for the car
What is your experience taking public transport (train, bus, tram) to work?	Positive, negative, Why, Why not?	Attitudes and subjective preferences for public transport
What types of transport modes do you have available where you currently live?	How would you rate their accessibility where you live and at your place of work?	Identify accessibility to other transport modes - enablers and barriers - if they did use other transport modes then what was their experience and what was the reason for them to change their transport mode. If they did not use other transport modes then identify factors which makes the participant why not to use other transport modes (inconvenience, comfort, access?)
Was there a time when you had to change your commute to work because of an event or you had to carry something in?	What was your experience?	Identify attitudes and subjective preferences
How much do/did you plan your journey before you set off?	To what extent would you describe your day-to-day travel as routine or repetitive; something you do an autopilot?	Identify any habitual practices of commuting

Topic/ Question	Follow up questions	Reasons for asking
How important was transport in your decision about where to live and work?	In the survey you said you have/have not relocated within the last 3 years. Was this because of work?	Assess impact of relocation if participant has relocated.
Environmental Awareness - Pro-environmentalism – aim to identify participants environmental attitude		
Can you remember any greening actions or sustainability campaigns that the University used to organise and promote?	(Check if participant mentions Transport travel options) How did this impact your commute to university?	Identify awareness of sustainability campaigns and whether participant might have been an active member or practising sustainable methods (recycling, travel).
With reference to your current place of work have you received any specific environmental training?	What type of training? (specify the type of training: courses, seminars, work groups etc)	Identify if workplace supports environmental behaviour which can influence participants type of commute
	Would you propose any actions to improve sustainable transport at your firm?	Open question for participant
Aim is to see whether the services offered by MaaS are attractive to participants leading them to consider a service such as MaaS to be of use for them.		
There is this idea of shared car and taxi rides or shared and pooled commuting.	Have you seen these services around? How did you hear of them?	Test participants knowledge on available shared mobility services
Personally, what do you think about using these services?	Would you be willing to use such services? Why, Why not?	Identify participants reactions and willingness to use such services.
Do you know anyone who uses these services?	Do many of your friends and family use car sharing, public transport? Would you say majority or minority?	Identify social influences on participants opinion about shared mobility services
What would your family and friends think about you using public transport?	Would you say they would/would not support you?	Social norms - identify how social norms influences participants mode choice
Aim to introduce MaaS and gather first thoughts in the light of the current situation (COVID-19, Work from Home, Clean Air Zone and Traffic Cells Initiative)		
Explain what MaaS is show infographic	Have you heard of this concept before?	Identify whether participant has any previous knowledge on MaaS

Topic/ Question	Follow up questions	Reasons for asking
Now that you have been introduced to the concept of MaaS. What is the first thing that comes to mind about this new digital planner?	Most important factors and features you would expect MaaS to have? Why?	Features and factors that the participant would want a mobility planner app to have
Do you think MaaS fits your current/previous travel needs?		Know how the participants thinks MaaS can fit their mobility lifestyle
What would make MaaS appealing for you to consider using it?	Specific features?	Check for preferences
Introduce the Traffic Cells Initiative Map and explain how it works.	Have you heard about this?	Check for previous knowledge
What do you think of this?	How do you think this will affect your commute pattern? Or any other travel that you do in the city centre?	Identify how the Traffic Cells Initiative might influence the participants travel behaviour
Given these planned restrictions into the city centre, do you think MaaS can be a potential to commute into the city centre?		Identify whether MaaS can be a potential tool for navigating public transport using an intervention such as the Traffic Cells Initiative
How has working from home affected your usual day to day commute?	If given a choice to continue working from home, would you consider changing your usual commute to the shops or other non-work activities?	Working from home more might lead to less use of the car and consider giving up the car if car sharing would be an option and the participant is comfortable with car sharing.
Personally, how has the pandemic affected your usual day to day commute, if at all?	what changes have you seen and experienced?	How has COVID-19 and the restrictive measures of travelling affected the participants usual travel behaviour
Looking in the long term with the vaccination and COVID risks reduced, would these measures change how you travel?	vaccinated - COVID risks reduced - would you change your habits?	With lower risks to health would participant change their usual transport mode post-COVID?

Topic/ Question	**Follow up questions**	**Reasons for asking**
What do you think is the impact of transport on the environment?	Do you think as an individual you need to do something to solve these issues? What about the role of the rest of society?	Close the interview with a focus on the impact of transport on the environment to gauge participants view of the issue and whether participant identifies any changes that can be done on an individual or national level that can feed into transport policy
What other things do you think we have yet to discuss what you believe to be important, given our topics so far?		Open question to participant

End recorder

Close interview

Appendix D

Default Question Block

Thank you for choosing to take part in our study.

We are looking to interview university graduates in employment, on their past and most recent commute patterns.

Taking part will consist of a one informal online interview that can take around 45 minutes.

Participants recruited for the interview will be compensated for their time with a £20 amazon voucher.

Requirements to be eligible to participate:

• You have graduated in 2018, 2019 or 2020
• You have your place of work located in the West Midlands,UK
• You have access to the internet and a computer, smartphone, or tablet with access to Microsoft Teams. (Microsoft teams is available online for free) (if not, the researcher will make other arrangements)

Before you can be selected for the interview, we kindly ask you to fill in this 2 minute survey.

You will be asked socio-demographic questions and quick questions on your travel behaviour which will determine your eligibility for the study.

We greatly appreciate your support in this study.

All data collected in the study will be held anonymously and securely and will only be accessed by the research team at the University of East Anglia. This study has gained ethical approval from the General Research Ethics Committee at the University of East Anglia, Norwich, UK.

By clicking 'Yes' to take the survey, I consent to participate in the survey and for my data to be used for its stated purpose.

○ Yes
○ No

Block 1

Which UK region do you reside in?

In which year did you graduate?

Are you...?

○ Male
○ Female
○ Other
○ Prefer not to say

How old are you?

Do you have a valid driving license?

○ Yes
○ No

Do you own or have access to any of the following vehicles?

	Own	Access to someone else's	Neither own nor have access to someone else's
Car	○	○	○
Van	○	○	○
Bicycle or Electric bicycle	○	○	○
Motorcycle, moped or scooter	○	○	○

Do you have any children aged 0 to 17 living at home with you, or who you have regular responsibility for?

○ Yes
○ No

What is your employment status?

○ Full-time
○ Part-time
○ Other

Have you relocated residence in the past 3 years?

○ Yes
○ No

How has your commute changed soon after travel restrictions and lockdown measures started?

○ I continue to commute to work
○ Used to commute but now work from home
○ Used to work from home and still do
○ Used to work from home but now I commute
○ Other

How are you currently travelling to your place of work?

- Walking
- Cycling
- Driving
- Passenger in private car
- Public transport

On a typical day, how long is your trip time from home to your place of work, one way?

How did you previously travel to your place of work?

- Walking
- Cycling
- Driving
- Passenger in private car
- Public Transport

On a typical day, how long was your trip time from home to your place of work, one way?

Is your place of work located in Birmingham?

- Yes
- No
- Prefer not to say
- Don't know

Is your place of work located in the centre of Birmingham (within the A4540 main ring road)?

- Yes
- No
- Prefer not to say
- Don't know

We would now like to ask you about your total household income (before tax).

Please note this will be used only for statistical purposes and treated with strict confidentiality.

Do you have any long-term physical or health issue that limits your ability to travel?

- Yes
- No
- Prefer not to answer

Thank you for completing the survey. The researcher will notify qualified candidates within one week.

Please leave your preferred email address where the researcher can contact you on.

Many thanks for your help and co-operation.

Appendix E

COM-B components	TDF Domains	Sub-themes	Quotes	Frequency out of 27
Psychological capability	**Knowledge**	Awareness of the available public transport in close proximity to where participant resides	"Yes, so there was always quite a lot of buses because I lived off a road where it's sort of like one of those main roads that sort of has loads of buses going to and from into it the city centre. There was always taxis and sort of Ubers and things like that... they've built a tram line recently but that wasn't around when I was there [university]." "I mean I could have taken the bus at the other end or something occasionally if I was really late and I couldn't wait for the next train at Birmingham station. I get a taxi to campus if I was really in a rush, yeah I don't drive so that wasn't available to me." "I could get there's like scooters this company have put around for hire but seems to be popped up around Birmingham so I could get on one of them but it doesn't make sense when I could just walk or I could ask for a lift but yeah those are the ways [to get around] bus, walk, scooter or lift."	26
		Awareness of at least one shared mobility service available in the area as an alternative to public transport	"yes, I've seen the electric scooters sort of before the last lockdown I saw more of them I think they're by a company called Voi. " "where my parents live, I've seen the carshare as well." "I think the scooters are great me and my partner went out a while ago just to try them out they're really good idea and they work well."	21

COM-B components	TDF Domains	Sub-themes	Quotes	Frequency out of 27
		Beneficial to have an induction day that included information on how to travel including personal travel plans	"I had to catch like 3 or 4 buses just to get to my university campus. It wasn't until my last year it's when, so my finals and my third year, when I found out you can actually catch one bus towards the university and I thought like no one really told me about because in the induction day they don't really talk about commuting they don't talk about people who don't have access to cars or to trains."	3
		Awareness of current travel schemes offered by the workplace	"we have a cycle to work scheme." "I use the train corporate scheme." "I know that we kind of loan bikes to staff if they want to try out cycling to work and for a short period of time and I think they offer kind of support with having bike checks."	8
Psychological capability	**Skills**	Mobile applications help participants to navigate public transport and shared mobility services	"I just think it's convenient the fact that you can order it on your phone, pay on your phone and it's all automatic." "I always check the train time when I wake up so I kind of plan how long I have and I book my train just on the app, [the] trainline app on my phone, so I know what time the trains are going to be." "I'd think there was an app or something you could see when the bus was coming and that was quite useful because it could be quite late sometimes [if] it left early for some reasons which is not helpful."	11

COM-B components	TDF Domains	Sub-themes	Quotes	Frequency out of 27
		Lack of skills and experience in using public transport	” I wasn’t confident with trains. I've never been on a train myself so I didn’t know and I was like just in case I get lost what am I going to do, [I] didn’t know where to get the train [and] where is it going to stop.” "there’s a bus station close to me but I don’t know how to use it." “I would never take a train on my own and that’s just because I don’t have a lot of experience getting on a train.”	7
		Information is needed to know how to use an electric scooter	“a couple of weeks ago... we saw [the] scooters outside and they looked like the council put them there and then you could go rent them but we didn’t see anything that looked like it’s being rented.” “I don’t think they're very well kind of publicised how to use them [electric scooters] so I know that I think you have to download an app but as a resident of Birmingham I don’t know which app it is, I don’t know how it actually works, so that’s made me more hesitant to give it a go.” “I don’t even know how that [electric scooters] works I assume someone takes it whenever they're ready and go I don’t know how it works but I definitely seen them and heard about them on the news.” "I've seen a lot of electric scooters around I'm not sure how you go about using them but I've seen a lot of them."	6

COM-B components	TDF Domains	Sub-themes	Quotes	Frequency out of 27
		Gaining the skills and confidence to use public transport through trial and error	“At the start I usually take two buses but then I discovered there was one bus that left from my stop to a stop close to university but it took me maybe more than 6 months before I discovered another number going to that direction.” "I think it made me more confident to use public transport when I needed to so it wasn’t something, I was very confident with before trying like figure out different bus routes and things, like that was not something I was good at. So, I feel like now I have that experience of using public transport, I'm now more willing to look at different options if something does happen." "in my first year I had to catch like 3 or 4 buses just to get to my university campus it wasn’t until my last year it’s when so my finals and my third year when I found out you can actually catch one bus towards the uni."	3
Psychological capability	**Memory**	Using public transport is habitual and done without seeking other alternatives	“it is quite repetitive…in the beginning ok like you work out if I take this to this place, I’ll get here so I try this route today then try this one tomorrow. I think [it] took me about a month or so to get to figure out the exact route or the best route for me to use.” “I know how often the trains are and that, so I'd often check if they’re running on my phone before I leave to see if they're delayed or not, I know exactly what time to leave my house to make sure I'll get there and be able to walk to the station from where I park and be there on time so I plan pretty heavily yeah.”	11

COM-B components	TDF Domains	Sub-themes	Quotes	Frequency out of 27
		Familiarity of using public transport continues to be used when commuting to work	"I think having the familiarity with the train line from when I was a student that had become my regular mode of transport." "I was used to the bus journey because I used to get the bus to go to college as well so I was quite confident to get the bus and get to where I wanted to go." "I think there's a bit more confusion with buses to me about how regular they are where they stop, where you need to connect from place to place. I think trains maybe I just spent more time on trains and I'm a bit more used to it but with buses I think it's a bit more difficult trying to understand which one connects to which one."	3
		Carsharing is something you do when you're a university student	"I carshared with some of my housemates on several occasions especially before I got my vehicle. " "sometimes it would be someone else driving all four of us or five of us and sometimes we'd kind of take it in turns so me or somebody else." "I got lifts with friends a lot when I was younger... I was 22 years old when I got my licence so for five years effectively, I've been getting lifts with friends…and in the beginning that was fine because everybody does that for the first one or two years." "a couple of times [carshared] with a friend she has a car if like we were staying late and we just thought we just go home together she didn't live too far from me."	7

COM-B components	TDF Domains	Sub-themes	Quotes	Frequency out of 27
		Carsharing for work or leisure purposes	“The people I know in Birmingham have mostly got the same job as me so we all carshare in our little community but not in a formal sense.” "I would go to football training or play football each week. I would always rideshare and take multiple people with me."	2
Opportunity				
Physical Opportunity	**Environmental context and resources**	Living close to campus or place of work does not require the use of public transport or shared mobility services	“I walked it was close enough too, so it wasn’t a problem. In my placement year I had to get the bus to and from placement and then in final year I moved a couple of miles away and I'd say probably 90 to 95% of the time I’d still walk [or] sometimes I get a bus in.” “I walked. I lived probably at most 15 minutes away from all my courses. Everything was very contained so yeah it was all walking. “ “Always walked or actually my degree I had some lectures that were off campus in a different location so I actually took my car.” "I live close enough to everything I need to get to and if I need to go further out then the transport options are there for me, I got the bus, the tram, the train [and] taxi."	13

COM-B components	TDF Domains	Sub-themes	Quotes	Frequency out of 27
		Not having a driving licence impacts your job search	"I don't have a car so anywhere that I can't walk to I need to get public transport [otherwise] I wouldn't be able to take the job." " I don't drive so [if] there was no transport links I wouldn't have any way to get there so if I was searching for a job it had to be based in the city centre really or around there so I could get to it." "I don't drive I need to be near a train station or within walking distance."	9
		Whichever public transport service is the closest to home or workplace it is most likely to be used	"I could have taken the train but it would just probably been more of a hassle getting to a train station because the bus stop was walking distance from my house." "it's actually quite easy to access [public transport] especially buses, so I'm still near the area of university there are quite a lot of buses that lead me to town and there's a train station nearby...there's a train station nearby my work place, there's a direct train but if I get a bus I have to change, I have to stop by town and then change another bus." "I think to get there I was always put off by the busy drive in kind of rush hour and things like that, the fact that it has a train station on campus it's a really attractive component of the university so the fact that I live 10 minutes from a station kind of makes sense to make use of that." "I think there is a bus that would take me into Birmingham but it's just easier to get the train I'm closer to the train station."	13

COM-B components	TDF Domains	Sub-themes	Quotes	Frequency out of 27
		Commute distance	"my previous job did teach me that I don't want a long commute and I was commuting from Harborne to Sutton Coldfield every day and so my partner would drop me off at the train station and then I'd get a train up to Sutton...but what I used to do was get a bus and then a train and it would just take forever and I finish at half five, so getting home in the night and leaving about seven in the morning so it was too much." "I wanted to be fairly close to my place of work so I didn't want an excessively long commute because before university I had a job where I commuted [for] a really long time and it just wasn't for me." "I would just do the same really look for jobs that [are] within the Birmingham area and not too far as where I currently work in Solihull which is obviously further out than Birmingham, but its within my timeframe that I'm ok driving and like it's not too far away and I don't really have to go on any motorways because I would rather avoid commuting on motorways on a regular basis. " "in the future I would much rather stick to something that is closer to home because the location that that [current workplace] is in as well there are no public transport links that I could get from Birmingham." "I wanted something close to home. I was just like I don't want to waste 40 minutes travelling to a place it just wasn't worth it for me."	9
		Nearby transport services need to serve a person's travel needs	"despite the fact I lived very close to a pretty busy railway station it didn't factor into my commute at all because it was not going in the right direction."	1

COM-B components	TDF Domains	Sub-themes	Quotes	Frequency out of 27
		Inaccurate live travel updates and services not being on time	“sometimes the times displayed [would] not really correlate to what was going on but most of the time it was ok.” "I think my experience with buses are that they don’t always come on time and you can just wait for a long time especially during rush hour. Pre-COVID you could just sit on the bus for ages and it’s not moving especially if you're going towards town. [The] trains comparatively are more reliable but sometimes it delays but it’s not as bad as buses." “I mean it was alright it just I got put off by it, by the reliability.” "the only time I've taken the car is when it’s really important and I need to drive maybe I have an interview or something like that and I don’t want to be late otherwise I used to take the train all the time [into the city centre]."	9
		Inconvenient and expensive to switch public transport modes	“when you got bus pass its free for the whole day and the bus for the whole day so I try not [use another mode of transport] but sometimes some places it’s just easier to travel by train [but] because I have got bus pass I have to travel by bus and it takes the double of the time to travel to the same place.” “the only mode of transport I can have access to would be the bus because that’s obviously, I can catch the train obviously, but then if I bought a bus ticket that means I have to waste money again to buy a train ticket and I wouldn’t want to do that.”	7

COM-B components	TDF Domains	Sub-themes	Quotes	Frequency out of 27
		Lack of direct bus routes	"I think where I live the transport links are quite bad there's no way, I can get to the train station without walking for maybe half an hour. I could get a bus but again this sort of issue with connecting buses and things like that I don't want to." "if for example there was a direct bus route that took me to that town which currently there isn't, but there isn't any kind of route like that if there was, like there used to be, I would definitely try and take that more. Any chance I can [to] reduce using the car I would definitely do but ultimately for you know distances that are longer than a set amount I would still use the car I think." "the fact that I mean the nature of public transport has to go all over the place and not directly and that was just sort of if you were in a rush, it's a bit sort of frustrating in a way because you're going so slowly." "it got to a point where I had to change midway through my journey and get another train and maybe a bus after that and that was when it was sort of like public transport wasn't the ideal solution than it would be [with the] private car."	8
		Shared mobility services not well thought off	"you need to use them [bicycle sharing] to get say from the train station to campus that's what they're needed for, but you can't do that because there's no docking station at the train station."	1

COM-B components	TDF Domains	Sub-themes	Quotes	Frequency out of 27
		Not having regular services	“where we live train times aren’t as regular as I'm used to…so when I'm coming back I can't just go to the train station and go oh there’s a train it’s like I have to wait an hour for a train if I've just missed one, so that little bit I wouldn’t say it’s difficult it’s just a change from what I was used to before.” "I used it [bus] as a student and where I lived it wasn't particularly good, they were quite infrequent and because I could drive I just tended to use that instead." "on the weekends it [frequency of the bus service] dropped to I think half an hour frequency if it was on time so driving for me was even more important than because I can get in [and] I saved probably an hour a day doing that by driving."	3
		Using public transport and shared mobility services is expensive	“I think the train is so expensive and again I might get the train somewhere but I’m still probably going to have to Uber to the exact location on the other side or to get home again so then that’s another additional cost.” “the bus is useful and it will go into the city centre so the bus is quite useful but it’s expensive so I never use it.” “I could have got a bike but at the time I didn’t really want to pay for a bike I think walking was the cheapest and healthiest option for me at the time.”	13

COM-B components	TDF Domains	Sub-themes	Quotes	Frequency out of 27
		Not enough parking spaces and parking is expensive	"always liked the idea of being independent going places on my own. Not having to get public transport was a big reason I wanted to get a car but when I did get it, I was there like yeah, I'm going to drive to university everyday I'm going to do this and I didn't just because how expensive it was to park. University parking is absolutely ridiculous." "I either walk to the city centre or I cycle or I would drive if I needed to but parking in the city is not great." "I like using it [train] if I'm going into Birmingham, I'd rather go on the train than drive just because it's easier you don't have to find a parking space or anything like that but yeah like it's really easy."	11
		Living or travelling to a rural area	"I use kind of the country roads country lanes to get to work so there's no traffic which is why it takes me so little time but it's about 7 miles away so I wouldn't be able to walk it and there's not really any bus routes and I don't know anybody else who works at the same place who lives near me that I could car share with. I think it would [be] pretty much impossible for me to not drive to work unfortunately." "we are so out in the sticks that there isn't a bus service, so people wouldn't be able to get the bus." "because I work in agriculture and farms are often in the middle of nowhere [I have] never been one for public transport because it's not accessible where it's just relied on having a car to get to wherever I need to go to work."	5

COM-B components	TDF Domains	Sub-themes	Quotes	Frequency out of 27
Social Opportunity	**Social Influences**	Being judged	“I think the bicycle thing will be more well more received than me being like oh ye I’m going around on the scooter. I think my dad would probably call me an idiot.” “I'm not massively inclined to use like a scooter or anything like that mainly because I don’t know how to use one. I wouldn’t want to borrow one and break it and embarrass myself and fall off.” “I think probably I would get a bit teased if I was going to work on an electric scooter everyday day.”	5
		Parents and relatives being available to drive participants to places	“I never actually just used it [public transport] all that often throughout my life. Like I've always had someone who's been able to drop me off or you know particularly where I need to go so yeah, I've never really actually used public transport.” “I could get my dad to drop me.” “I'm surrounded by cars...if my mum is not available, I can call my dad if not, I can call my partner.”	7
		Social and family pressure to get a driving licence and stop using public transport	“If you hear someone who doesn’t have a car like an adult, you’ll be like oh why not.” “all of my family are like you are nearly 24 why are you not driving … but I do have to do it within the next few years or because in the future so many jobs are going to say we really need you to drive.” “my parents had always instilled in me that as soon as you turn 17 you learn to drive.”	6

COM-B components	TDF Domains	Sub-themes	Quotes	Frequency out of 27
		Family and friends' negative reaction to participant using public transport or shared mobility services	"my family are very antipublic transport and I think for that reason I haven't used it a lot growing up and that's why I don't. My friends all of them have their own cars." "my family's reaction if I was using the ridesharing service they'd be like, but why don't you have your own car." "my family and friends, I doubt they would encourage it [to use public transport and shared mobility services] they would encourage me more to do those things just because it saves a lot on petrol money. So, the amount of money I spend every month on petrol is ridiculous and in terms of fitness so cycling shares like bike sharing could be fitness as well."	6
		Family and friends would comment on how safe it is to use public transport and shared mobility services	"they'd have no problem with it [using public transport and shared mobility services] at all. I think if I was ridesharing they'd think that was fine, cycling I think they'd be a little bit more mindful and perhaps a little bit anxious about me being on the roads just as I would be." "I think so long as I knew whoever I was sharing with before I decided to share with them and it wasn't a stranger they wouldn't think any differently." "I don't think my parents would be too keen if these are people just complete strangers. I think I'd be apprehensive at first, but I imagine you'd adapt it 'd be fine."	10

COM-B components	TDF Domains	Sub-themes	Quotes	Frequency out of 27
		Finding support from the workplace and carsharing with friends	"I went into different schools and I shadowed people doing their jobs and stuff like that and did some office based work so I was I think because I didn't have my driving licence at the start they were very good in sort of saying we'll get you to work with local schools which are within walking distance to the office so when I was commuting from the office to those schools I would walk." "Occasionally I would Liftshare if actually I think quite often because the people I lived with would be in the same course and then our neighbours were doing very similar course. We would just take it in turns to drive." "In my last year we had a lot of placements, so we had to travel to different schools. So, when we did travel to lots of different schools then we shared cars, so we did carsharing and that was really handy."	8
Motivation				
Reflective Motivation	**Social/Professional role and identity**	Identifying as a parent to young children more inclined to use the car	"how I travel with them ok I would want them to be healthy cause I want them to be healthy and totally safe." "when you have children around … you're not going to make your child walk 15minutes or catch the public transport. You'd rather drive them yourself." "the more children that I had the harder it became to either relying on other people or catch the bus to be honest I never caught the bus, I caught taxis which is obviously very expensive so getting them to school and nurseries and different things like that."	3

COM-B components	TDF Domains	Sub-themes	Quotes	Frequency out of 27
		Discounted travel for students	“there was a special kind of deal for students. It [public transport pass] was about £30 to £35 for a month and you could use it as much as you want so that’s what I used. It was quite good I thought." “that’s the good thing about buses and I know trains do have them, but it is really handy for students having them student cards just because it is a lot less expensive as well.” “I had a 3 monthly pass and, so I was only doing it [work placement] for 3 months so I got the pass for that time for a student discount." "I think most students have a railcard. I know I certainly had one throughout my time at the university and that was really helpful because it brings the cost down as well."	13
		Being environmentally conscious	“I think I care about the environment so much I would have got my car a long ago and making short journeys when I could just walk.” “I think that [being environmentally conscious] does contribute to my reluctant to learn to drive because it actually isn’t good. When we could go abroad, I rarely did and I'm conscious of using planes and stuff in terms of everyday transport I do, I like to use the train because of the fact it’s probably one of the best [environmentally] that is widely available.”	4

COM-B components	TDF Domains	Sub-themes	Quotes	Frequency out of 27
		Working schedules are not served by public transport	“because I also took on quite a lot of extra curricula activities during my whole degree and I was often quite busy, I was often on campus until quite late. Often had to be there early in the morning. My daily schedule was quite different to most students because of that I found it was easier to drive because I didn’t have to worry about carrying things or when’s the last bus and things like that.” “commuting to work isn’t too bad I found it a lot easier since I've been driving it’s been so much easier because I work in retail so I'm doing 5 o’clock in the morning starts 6 o’clock in the morning so it’s just so much easier getting in my car going myself instead of waking my mum or dad up to take me or getting a taxi because most buses don’t really run that early so it is way more convenient for me.” “we come in so early and we leave quite late in the evening and especially during the winter months it’s both really cold and quite dark as well. So, like a safety factor could be included in that where it’s better for you driving.” “I would start at 8am and I would finish at 5pm. So, I needed to be at work before 8am and the shuttle bus left at 8am so I had to drive and then I had to do every other weekend I had to go [into work] so using the shuttle bus wasn’t really feasible especially on a Sunday because it didn’t run on a Sunday so driving was essential during the placement.”	7

COM-B components	TDF Domains	Sub-themes	Quotes	Frequency out of 27
		As a woman using public transport or a taxi is not considered to be safe	“I think with like carsharing with somebody that I knew then I wouldn't have a problem with it like if it was somebody that I work with but I think the idea of it being with people I don’t know it’s a little bit more of a safety concern like as a woman I am a bit more like I can’t be getting into cars with people I don’t know even with taxis that’s why I don’t get them a lot because at the back of my head I’m like I don’t know what’s going to happen if I get into this taxi which is why I tend to avoid it a little bit more.” “I know it sounds really weird, as a girl, a young girl on a bus sometimes... I've had experiences on buses when people approach me and I’m like get me off the bus. So yeah, it does come down to safety I think.”	2
		Working in the educational sector	“I’m an arts teacher sometimes I will bring it [environmental practices] into my lessons the way that I teach them [students] and try and get them, their attitudes towards [being] little bit more eco-friendly.” “I felt a little bit guilty so there was me and three of the teachers in my class and the kids where kind of shouting at us miss why are you driving to work and then I sit there and think I'm a teacher, I'm going to be a teacher and I'm not really setting a good example for these kids.”	3

COM-B components	TDF Domains	Sub-themes	Quotes	Frequency out of 27
		Workplace is in a rural area	"you need to have a car because if you are going to a gig public transport is usually not running by the time that gig is finished. It finishes 11 o'clock no trains no buses you need to drive back sort of thing and its quite likely it will be in the middle of nowhere anyway." "I live in a village and I work in another village and I use kind of the country roads country lanes to get to work so there's no traffic which is why it takes me so little time but it's about 7 miles away so I wouldn't be able to walk it and there's not really any bus routes and I don't know anybody else who works at the same place who lives near me that I could car share with I think it would pretty much impossible for me to not drive to work unfortunately." "Public transport doesn't really exist [at the place of work]. There is no train that I could take to get from Telford to Newport and then even if I could get to the nearest town, I would have to get the bus. So, driving really is the only way to access the uni."	4
		Having placements as part of the university degree allowed participants to test using public transport for their job	"there's a lot of home visits and I think during my placement I just experienced how I waste a lot of time to get on public transport. Say I can only visit two families a day with public transport, one in the morning and one afternoon that's it even though it's just a 1 hr retake but it took me 2 hrs to get there and come back so it's just saved more time if I could drive." "we had a lot of placements so we had to travel to different schools so when we did travel to lots of different schools then we shared cars so we did carsharing and that was really handy." "I volunteered as a research assistant for some of the time and that involved travelling to primary schools so that changed it [travel pattern] up a bit."	10

COM-B components	TDF Domains	Sub-themes	Quotes	Frequency out of 27
		Promotion of cycling and public transport use at work	“I think it's good that there is cycling scheme at my work for staff but there's not much else really. So, they do help with the train travel subsidizing of the train pass and support with that so that encourages people not to drive.” “it’s the role of places like companies and schools and places like that, to push for initiatives like carsharing.” “we have a cycle to work scheme. You can also have like other schemes whereby you're lent a bike... those are available and they're kind of promoted really well as well. I use the corporate scheme to get my travel pass so that’s also pushing for people to travel using public transport as well and I think obviously there's limited car parking on campus so they do try to push that not everyone can come on campus by car and if you can choose a more relatively sustainable option then you should try to do that.”	7
Reflective motivation	**Beliefs about capabilities**	Using one public transport mode over another because it’s easier.	“I wasn’t confident with trains. I've never been on a train myself so I didn’t know and I was like just in case I get lost what am I going to do didn’t know where to get the train where is it going to stop, I just thought the bus would be the easiest option.” “there were bus routes available I think I wasn’t really familiar what the routes were and where you could get to and also how regular they were and just kind of how it works. The train was always the most convenient and easiest method to use.” "if I'm in a carshare it's obviously it's much easier to drop your stuff in the booth and you know jump in the car and you're good to go."	9

COM-B components	TDF Domains	Sub-themes	Quotes	Frequency out of 27
		Cost and service schedule makes public transport difficult to use	“it's not just the fact that I have to use multiple trains. I think it was the time as well sort of from where I live if I had to go to Warwick university, I think I looked up on the train what it would be like and I had to get there by half 9 and I'd have to leave about 6:30/7:00 in the morning...if I drove it would be maximum an hour even with traffic it would still be quicker to drive. So, it was I think it was more the time than anything because I had a railcard so I could it was still within the West Midlands area so it wasn’t a cost problem it was time and difficulty.” “I could have got the bus if I couldn’t drive but it would have been really difficult. I would have gotten a bus from my hometown into the city centre and back out again and it would have taken about 2 hrs in total so I opted to drive since I could…the train would have been quite difficult because I would have to get a train into Birmingham city centre and there wasn’t really a station near the university so I would have to get a train next to the nearest station then a bus.” “the train isn't really an option to me. I could walk to a train station but again that would take longer to get to a station and get in then if I just drove.”	18
		Method of payment	“I just think it’s [Uber] convenient the fact that you can order it on your phone, pay on your phone and it’s all automatic I think a lot of conventional taxis expect you to have cash which I never do.” “one of the things that’s put me off using the bus in Birmingham before is that sometimes they only accept cash which is super annoying now when things are with more contactless I never have cash on me.”	2

COM-B components	TDF Domains	Sub-themes	Quotes	Frequency out of 27
		Easy to use public transport when going into the city centre because its quicker and less of a hassle than taking the car	“I like using it [public transport] if I’m going into Birmingham. I'd rather go on the train than drive just because it’s easier you don’t have to find a parking space.” “so the train is useful for a few specific journeys so visiting friends who live in Selly Oak which is one of the university parts of Birmingham and I was in the centre so that was really handy. If I was at university you could very easily get to Selly Oak or a handful to other places and really quickly the trains they're like every 15 or 20 minutes and they're fast so that’s super convenient.” “it's not car friendly going to the city centre anywhere so actually when I go to work I have to go across the town but I cycle so its fine and I know a lot of my friends if they're going to city centre they'd rather go by train than driving.” “when I had the car available on days my partner wasn't working or whatever it just seemed like a very, it was a lot longer to get in. You had to drive through the centre of Birmingham which is not enjoyable. Yeah, I just think it was a much easier option and I think that’s why a lot of people are using the train from what I know.” "I think a lot of people at work found it really weird that I could drive but I didn’t drive to work because they all did but it just didn’t make sense for me. So, I'd be paying for more petrol I would be in more traffic I'd have to park 15 minutes’ walk away and then walk, whereas if I get the bus it would take me to right outside work."	9

COM-B components	TDF Domains	Sub-themes	Quotes	Frequency out of 27
		Difficult to carshare because one would not know who to carshare with.	“I think with like carsharing with somebody that I knew then I wouldn't have a problem with it like if it was somebody that I work with but I think the idea of it being with people I don’t know it’s a little bit more of a safety concern.” “carsharing I would if there was people, I knew lived near me and going to work at the same time. Like I'd be more than happy to do it, I'd quite like not to drive to work so that I would be quite happy with that.” "I think car sharing is a great idea especially when you travel long. Yeah, if you travel to different city or if you travel to the same place every day and you're looking for a person who is going to the same place every day so I think that’s a good idea but I think because it’s not popular people are concerned with safety issue but I think it’s a great idea."	11
Reflective motivation	**Beliefs about consequences**	Ridesharing does not allow for a free schedule	“there could be a Liftshare sort of thing for the staff, but I personally probably wouldn’t partake in that just because you want the actual time in the morning and when you want to go home you just want to go home. I don’t want to be dropping someone else off.” “it takes an unnecessary level of planning if you're going to share just one car within a household. In terms of like if I had a colleague that lived close and we worked at the same place sharing lifts that way I think that would be a great idea but then again, I do make detours to places straight from work like to do grocery shopping and things like that, so if I did car share with someone, I couldn't do all those things.”	6

COM-B components	TDF Domains	Sub-themes	Quotes	Frequency out of 27
		Waking up early, at the mercy of public transport scheduling and getting back home late at night when using public transport	"at the moment it's not particularly pleasant to walk and I wouldn't get the bus now because it would make my journey longer, I would have to get up earlier." "So I do have a car. If I really wanted to I could take the bus but it could take a really long time." "there was definitely more planning with that because I had an app on my phone so I would check the train times and anything and from my university there was times where I would have to get certain train to near my parents' house or whatever so I would have to leave the lecture like 5 minutes early so I could run and get on this train ... it would be 40 minutes between each train there was much more planning involved." "so when I'm coming back I can't just go to the train station and go oh there's a train it's like I have to wait an hour for a train if I've just missed one. That little bit I wouldn't say it's difficult it's just a change from what I was used to before it's just the new way of thinking that I've got to kind of plan my journey home a little bit more than I used to." "It was more the early start I didn't like but that was scheduling more than the actual commute, obviously right if it takes 50 minutes to get there for a 9am start you kind of got to be awake at sort of half 6 so there's time to eat and stuff."	8
Reflective motivation	**Intentions**	Not taking the car but using public transport to go into the city centre	"I'm just a very nervous driver if I'm honest. If I don't know where I'm going, I find it really stressful…getting the train in and walking is just as convenient if not more convenient for me and significantly less stressful so I wouldn't personally take the car into Birmingham I don't really see the point."	1

COM-B components	TDF Domains	Sub-themes	Quotes	Frequency out of 27
		Using public transport and shared mobility services for nights out	“we used Uber if we went on a night out because that was the easiest and kind of the safest way of getting from our flat to the clubs.” “Usually if I had to get the bus somewhere it’s because I'm drinking and I won't drive.” “I'm normally a really big fan of Uber. I'm not really using it [Uber] at the moment because I'm not doing anything social that’s generally what I would do with it. I'd been out for dinner or drinks with friends I would always get an Uber home because I wouldn’t always feel like I wanted to get the bus later at night so I would always get an Uber.” “I guess if there's anyone [who] was drinking or if I wanted to drink and go somewhere then I'd get an Uber.” "if I'm going out in the evening, I'm not driving anyway."	6
		Intend to learn to drive if the job requires them to	“if my work wasn’t near a train station or a bus stop, I think I would be more compelled to drive definitely.” “I mean it’s a lot to do with the kind of locations of my jobs. If an opportunity was there, I would need to drive, I can learn and probably would consider learning to drive.” "I think if I found, I had a job and I really wanted it but it was just too far away I could do it [learn to drive] out of necessity, where something is inaccessible and the only reason it's inaccessible is because I can't drive yeah then I would be like ok time to."	7 (frequency out of 7 non-licenced participants)

COM-B components	TDF Domains	Sub-themes	Quotes	Frequency out of 27
		Relocating or choosing to stay because of nearby public transport modes for better access or to have a shorter commute	“we decided to live in this area because it was on the train line to where I work so I knew from my time as a student at university there was a station on the campus and how regular the trains where on the cross city Birmingham line so when we were looking for properties myself and my partner where looking for one on this train line and we wouldn’t have deviate form that because it meant my partner... she uses our car and we wouldn't want to get 2 cars I would prefer to commute by the train anyway.” “me and my partner work quite nearby to each other and we just... want to be able to walk to work or at least [have a] very short bus journey but we both just walked to work.” “I did limit where I looked [for work] in terms of how long my commute would be and when I moved house well I moved out of my parents’ house to here it was very much a where can I go that’s not going to have a really long commute for me so even now I'm further away from my place of work as I used to be my commute is a lot quicker because I'm not having to go through the city centre like I used to have to do… ideally I would have wanted to have been somewhere closer where I could have walked to work that was kind of my original criteria and it just so happened that that didn’t happen.” "if work did say to me you are going to work at this one location for the next 3 years I would consider relocating if I loved the job enough because the commute is just way too much and I know other colleagues that have actually relocated for roles." "I think work did play a part in it [relocating] I always planned to move anyway to where I am but work was a factor because I guess I had more options available to me living where I am now as opposed to where I did before. Where I lived was quite unconnected and rural whereas now, I'm quite close to the city."	12

COM-B components	TDF Domains	Sub-themes	Quotes	Frequency out of 27
Automatic Motivation	**Reinforcement**	Financial incentives to use public transport	"I get it's like a railcard they have on the train which makes it cheaper to use the train than the bus." "I think I see that it might be possible that you don't need a car because it's like insurance everything add up and they're not any cheaper than taking public transport." "something I really enjoyed about the pass was you could take family and friends up to one other adult and 2 children for £1 additional returns that was great and kind of use that. That's the main reason we use the train because that was a lot cheaper there was no issues of parking." "after 1st year I was just driving but there were other times my girlfriend was studying in Durham so with that journey I would sometimes take the train because if it was cheap and quite convenient you can do other things while on the train." "I would always take the train my girlfriend had a travel pass because she works in Birmingham and I travelled for £1 off peak so she travelled for free on the weekends she was already paying for it and I travelled for a £1 and several times we took the train... we used it because it was so cheap... I would never get the car to do that because the car is expensive to park in Birmingham."	5

COM-B components	TDF Domains	Sub-themes	Quotes	Frequency out of 27
		Financial incentives to use carshare and taxi or Uber services	“I don’t think carsharing is a bad idea. I think it’s quite helpful and handy especially it saves you with a lot of money because you are all chipping in on petrol costs and parking costs, so I actually think carsharing is actually really good. I would encourage people to carshare … I would definitely advise for people to carshare just cause it makes life so much easier.” “I very rarely go on my own [to work] if there’s someone who lives near me [who] I can take then we will organise that mostly because of a financial...it's expensive to pay for petrol and we can split cost.” “it would be so much easier to split the parking fee and I know in Birmingham it's really expensive parking everywhere so instead of like 4 of us having to pay £8/£9 for a few hours we would just split the cost and share it.” “there seems to be lots of free [Uber] vouchers that if you recommend a friend you get a £5 journey or whatever that was so lots of people were telling people about it because they wanted the voucher.”	7
		Making better use of commute time	“on the train I'm quite happy. I usually get a seat it's relatively quiet. I chose this mode of transport as well because I can do other things rather than just, I don’t need to concentrate on anything, I like to read so I usually read or listen to a podcast on a train which I wouldn’t be able to do if I did drive.” “I would sometimes take the train because if it was cheap and quite convenient you can do other things while on the train." "with the nature of driving I can't use that time productively like if I was sat on the train and I could do some work for something else I have to be focusing on the journey."	3

COM-B components	TDF Domains	Sub-themes	Quotes	Frequency out of 27
Automatic motivation	**Emotion**	Safety	“whatever you do you have to be security conscious so that the time I explored the option [to carshare] not in the UK it looked like a good idea but then you have to meet people. I would have felt comfortable with people I know, I never used it I just explored it then but I would have felt more comfortable with people I know rather than strangers.” “I've had experiences on buses when people approach me and I’m like get me off the bus so yeah it does come down to safety.” "for safety reasons I don’t think public transport is particularly safe. Like in terms of potentially being robbed or being harassed or that kind of thing if I'm in my own car then I know that I’m not near any of that kind of danger." "I don’t necessarily feel massively safe in an Uber I think I would rather be on a bus where there’s 15 people and I feel that yeah nothing could happen here." "You are still safe in your car when as driving your bike, when it’s raining especially, if you are riding on a road you are putting yourself at risk because there's so many cars and so much you have to look out for I wouldn’t do that."	19
		Public transport restricts your freedom	"I did I think for me it was the kind of freedom of being able to go where you wanted to go whenever you wanted to. In my first year of college used to get the bus to college and then I started to drive and always wanted to pass my test and I think it was being able to say right I'm in college at 10am today so you just drive to college to get there whenever you wanted to rather than being tied to particular buses and when they were available."	5

COM-B components	TDF Domains	Sub-themes	Quotes	Frequency out of 27
		Stressful experience	“When I had to get on two buses it wasn’t funny because at the time, I was going to university in the morning I usually walk, we had to queue in early morning and it wasn’t funny, so sometimes you had to stand to get to the city centre before I change buses and all that. So, it wasn’t a pleasant experience.” “buses I find stressful because I never know where I should go. The train you know your stops you know how many stops till you get off.” “bus service was regular, but it was quite packed buses every morning. It wasn’t a fun experience it was quite stressful particularly for a first year it was quite stressful really.” “I didn’t like it I hated it [the bus]. It was always busy and it was always a bit of a stressful time trying to make sure I could get in on time get to my lectures on time because I hate being the last person walking in and everybody’s been sitting down for a while it was just stressful.” "I'd be more likely to walk from the town centre I don’t think I would be able to get back on a bus again just because it’s a bit crowded and a bit stressful trying to make sure you are on time and everything.” "with buses its waiting for the bus time sometimes you miss the bus which can be frustrating especially missing a bus and then having to wait or if there's delays as well so that can be stressful."	12

COM-B components	TDF Domains	Sub-themes	Quotes	Frequency out of 27
		Frustrating when not having a good service	" I think it can be a bit frustrating sometimes to sort of the map system on Uber it doesn't seem great and I know the drivers don't always know the roads as well as black cab drivers so it can be slower than it seems like it needs to be really and also the app itself it's quite glitchy when it says the car is about to arrive or it's 2 minutes away and then on the map it jumps to somewhere totally different, that could be kind of annoying." "I do remember standing there with a big crowd of people and missing 2 or 3 buses in a row both directions to university and coming back home because there were too many people on them and that was really frustrating because I just wanted to get home and I was having to stand there sometimes for up to half an hour as well if you missed 2 or 3 buses." "I did find that quite frustrating because I liked to have my own routine or do what I want and having to be ready when they [carshare friends] were ready to go home I used to find that quite frustrating." "I mean the nature of public transport has to go all over the place and not directly and that was just sort of if you were in a rush it's a bit sort of frustrating in a way cause you're going so slowly." "the student card is obviously £30 or something like that annually and you can only use it after 10am which was slightly frustrating sometimes so I wanted to go in earlier and I wouldn't get the benefit."	6

Appendix F

Code	Workplace Commute (pre-pandemic	Driving Licence	Car Status	MaaS travel needs
P01	Bus	Yes	Access to someone else's	Yes, for commute and leisure purposes
P02	Train	No	Neither own nor have access to someone else's	No, rarely ever changes commute mode
P03	Driving	Yes	Own	No, need the car for work and leisure purposes
P04	Walk/Taxi	No	Neither own nor have access to someone else's	Yes, for leisure purposes
P05	Walk	No	Access to someone else's	Yes, for leisure purposes
P06	Drive	Yes	Own	Yes, for commute and leisure purposes, but highly depends on carshare availability
P07	Drive	Yes	Access to someone else's	Yes, for leisure purposes
P08	Train	Yes	Own	Yes, for commute and leisure purposes
P09	Drive	Yes	Own	Yes, for leisure purposes
P10	Walk/Liftshare	No	Access to someone else's	Yes, for leisure purposes
P11	Drive and Train	Yes	Own	Yes, for commute purposes
P12	Walk	No	Access to someone else's	No, everything is accessible by foot
P13	Drive	Yes	Own	Yes, for leisure purposes
P14	Drive	Yes	Own	Yes, to commute to the office but then commuting from the office to other workplaces makes it complicated. Would fit with leisure purposes.
P15	Drive	Yes	Own	Yes, for commute and leisure purposes
P16	Drive	Yes	Own	No, needs the car for work and leisure purposes
P17	Train	No	Neither own nor have access	Yes, for commute and leisure purposes

Code	Workplace Commute (pre-pandemic	Driving Licence	Car Status	MaaS travel needs
			to someone else's	
P18	Drive	Yes	Own	Yes, for leisure purposes
P19	Bus	No	Neither own nor have access to someone else's	Yes, for commute and leisure purposes
P20	Bicycle/Drive	Yes	Own	No, needs car to commute to office and from the office to other workplaces
P21	Bus	Yes	Own	Yes, for commute and leisure purposes
P22	Drive	Yes	Own	No, would not want to use public transport although MaaS could be useful for when having car issues
P23	Train	Yes	Access to someone else's	Yes, for commute and leisure purposes
P24	Drive	Yes	Own	Yes, for leisure purposes
P25	Train	Yes	Own	Yes, for commute and leisure purposes
P26	Drive	Yes	Own	Yes, for leisure purposes
P27	Drive	Yes	Own	Yes, for leisure purposes

Appendix G

Code	Workplace Commute (pre-pandemic	Driving Licence	Car Status	Thoughts about the Clean Air Zone	Works in Birmingham City Centre
P01	Bus	Yes	Access to someone else's	Prefer to use the bus otherwise taking the car would be expensive to pay for the parking and zone charge.	Prefer not to say
P02	Train	No	Neither own nor have access to someone else's	Might affect because trains will be busier if people are encouraged to use public transport. Initiative is positive although excludes people with mobility issues.	Yes
P03	Drive	Yes	Own	Commute time would be longer.	Yes
P04	Walk/Taxi	No	Neither own nor have access to someone else's	Great idea. Travelling to the city centre makes sense to use public transport unless travelling to pick up something really heavy.	Don't know
P05	Walk	No	Access to someone else's	Great idea.	No
P06	Drive	Yes	Own	Car is exempt for a few years although this will change moving forward.	Yes

Code	Workplace Commute (pre-pandemic	Driving Licence	Car Status	Thoughts about the Clean Air Zone	Works in Birmingham City Centre
P07	Drive	Yes	Access to someone else's	*"Ridiculously inconvenient"* Understands the need but public transport is not an option for their type of work. The CAZ will negatively deter people from visiting the city centre.	No
P08	Train	Yes	Own	Good idea. Certainly, needed in Birmingham.	No
P09	Drive	Yes	Own	Good idea. The less cars that go into Birmingham city the better.	No
P10	Walk/Car passenger	No	Access to someone else's	Zone charge is expensive. Prefer to stay local and avoid going into the city centre.	No
P11	Drive and Train	Yes	Own	Really good idea to reduce emissions and congestion in Birmingham city.	No
P12	Walk	No	Access to someone else's	Really good idea. People drive when they do not need to, and the CAZ can make a lot of people change their commuting options.	Yes
P13	Drive	Yes	Own	Great idea. Would never drive in Birmingham.	No
P14	Drive	Yes	Own	Good idea. Birmingham is well accessible through public transport. The increase in demand for public transport might affect participants travel but it might also attract more funding to improve the service.	No

Code	Workplace Commute (pre-pandemic	Driving Licence	Car Status	Thoughts about the Clean Air Zone	Works in Birmingham City Centre
P15	Drive	Yes	Own	Zone charge is expensive. People who have not got cars that meet the criteria for entering the zone would be better off getting public transport. Would visit the city centre only on occasions when participant needs to shop otherwise would prefer going to other places without having to pay a zone charge.	Prefer not to say
P16	Drive	Yes	Own	Understands the aim of the CAZ but paying for the zone charge and parking fee might be the same price as a train ticket. The convenience of driving and not having to carry any bags compared to getting the train, participant would be tempted to pay the zone charge and the parking provided it would be the same as a train ticket.	No
P17	Train	No	Neither own nor have access to someone else's	As someone who uses Uber to travel into the city centre the fare might become more expensive. Otherwise, it is still a good initiative.	No
P18	Drive	Yes	Own	It makes complete sense to decrease pollution in the city centre. Rarely visit the city centre but if so, the easiest option would be to drive to the train station and get the train into the city.	No
P19	Bus	No	Neither own nor have access to someone else's	It would definitely stop a lot of people using their cars however it might deter people from going into the city centre. CAZ will not impact participant because they catch public transport.	Prefer not to say

Code	Workplace Commute (pre-pandemic	Driving Licence	Car Status	Thoughts about the Clean Air Zone	Works in Birmingham City Centre
P20	Bicycle/Drive	Yes	Own	Good idea. Birmingham city centre is not car friendly and it's difficult to find a parking space or its expensive to park. Will not impact participant because they choose to cycle into the city centre.	No
P21	Bus	Yes	Own	Really good idea. People should be discouraged from driving into the city centre. Will not impact participants because they rarely drive in the city centre and would always choose to walk or catch the bus or taxi to visit the city centre.	No
P22	Drive	Yes	Own	Participant lives close to the city centre. They anticipate the CAZ will make car drivers park close to their residential area to avoid paying the zone charge. The participant said their residential area already has parking issues thus with the CAZ this can be worsened as more drivers park their car in the area.	No
P23	Train	Yes	Access to someone else's	Good idea but more park and rides at public transport services need to be created so people can leave their car close to the station, travel by public transport and avoid paying the zone charge. Participant would not be affected because they use the train to visit the city centre.	Don't know
P24	Drive	Yes	Own	Participant will be affected and thus considering cycling or walking as well as relocating their personal office. Nevertheless, the CAZ is a good idea to reduce the number of cars in the city centre and to have a zone charge in order to be pushed into not driving to avoid paying the charge.	No

Code	Workplace Commute (pre-pandemic	Driving Licence	Car Status	Thoughts about the Clean Air Zone	Works in Birmingham City Centre
P25	Train	Yes	Own	Good idea. Birmingham city centre is well accessible through different transport modes. Likely to have little to no impact as participant would not choose to drive into the city centre.	No
P26	Drive	Yes	Own	Participant chose to buy a car specifically within the criteria to be eligible to drive in the city centre.	Don't know
P27	Drive	Yes	Own	Fully support the CAZ but shame it does not provide exemptions. Usually, participant always uses public transport to travel into the city centre because parking is too expensive. Sometimes driving into the city centre is unavoidable when travelling to pick up something heavy. Thus, driving into the city centre will become more expensive with parking and the zone charge.	No

Appendix H

Code	Workplace Commute (pre-pandemic	Driving Licence	Car Status	Potential for MaaS with CAZ and Traffic Cells Initiative	Works in Birmingham City Centre
P01	Bus	Yes	Access to someone else's	Would be cheap compared to driving and paying for parking and the zone charge. Otherwise, if getting into the car is cheaper than a MaaS subscription, people would get into their cars rather than pay a MaaS subscription.	Prefer not to say
P02	Train	No	Neither own nor have access to someone else's	Could be beneficial for people who are not familiar with public transport modes. MaaS would be convenient giving you the best options as well as a range of options in case one transport mode is busier.	Yes
P03	Drive	Yes	Own	Would consider MaaS if they can get to their workplace faster than them driving.	Yes
P04	Walk/Taxi	No	Neither own nor have access to someone else's	Opportune time to introduce MaaS and give people the option of using alternative modes of travel. The CAZ and Traffic Cells Initiative would push people out of their comfort zones.	Don't know
P05	Walk	No	Access to someone else's	MaaS would be a really useful resource for people seeking alternatives.	No
P06	Drive	Yes	Own	MaaS can help car drivers looking for other alternatives to travel to avoid paying the zone charge.	Yes
P07	Drive	Yes	Access to someone else's	MaaS would be more desirable if it means one can avoid the zone charge.	No

Code	Workplace Commute (pre-pandemic	Driving Licence	Car Status	Potential for MaaS with CAZ and Traffic Cells Initiative	Works in Birmingham City Centre
P08	Train	Yes	Own	MaaS could be appealing for commuters travelling into the city centre because of its integrated service.	No
P09	Drive	Yes	Own	Would consider using MaaS if working in the city centre to avoid the traffic and parking costs.	No
P10	Walk/Car passenger	No	Access to someone else's	MaaS would be helpful when there are events happening in the city and transport becomes unmanageable. So, having MaaS to suggest best options for the day would be useful when travelling in the city centre.	No
P11	Drive and Train	Yes	Own	If there are limitations on your usual mode of travel of getting into Birmingham, you would need to look at other alternatives. However, if people are ridesharing through MaaS they would be splitting the cost of the zone charge and parking.	No
P12	Walk	No	Access to someone else's	Would be beneficial for people living further out of the city and need to commute into the city.	Yes
P13	Drive	Yes	Own	If people were restricted where they could go in their cars MaaS would potentially encourage people to find an alternative.	No
P14	Drive	Yes	Own	Depends on the cost, it might be easier to rideshare and split the cost of the zone charge.	No
P15	Drive	Yes	Own	Beneficial for people who do not have cars that meet the regulations.	Prefer not to say
P16	Drive	Yes	Own	The CAZ and Traffic Cells Initiative would force people to use public transport.	No

Code	Workplace Commute (pre-pandemic	Driving Licence	Car Status	Potential for MaaS with CAZ and Traffic Cells Initiative	Works in Birmingham City Centre
P17	Train	No	Neither own nor have access to someone else's	One can easily carshare and split the costs of the charge, however MaaS would make the train and bus travel easier from a customer perspective. The CAZ makes you think twice about getting Ubers because it could be a longer journey and the price could be increased. It would affect decisions on getting taxis.	No
P18	Drive	Yes	Own	Beneficial for people who work in the city centre. Car drivers can have a MaaS subscription alongside their cars.	No
P19	Bus	No	Neither own nor have access to someone else's	MaaS will be handy and useful as it provides users with the information, they need to use public transport. It would be beneficial for people from a different city coming to work in Birmingham.	Prefer not to say
P20	Bicycle/Drive	Yes	Own	Beneficial for people who might not be familiar with public transport and need to travel into the city centre.	No
P21	Bus	Yes	Own	People would need to see the benefit of using the app, especially car drivers who do not see driving as costly compared to public transport. Some people might choose to wait until they have a reason to visit the city centre to make it worthwhile for them to pay the zone charge. Thinking of future job prospects the CAZ and Traffic Cells Initiative might affect participants goings and coming.	No
P22	Drive	Yes	Own	Most people already use public transport to travel into the city centre. However, whether MaaS would be useful is different. Frequent travellers into the city centre like commuters might be interested but people who visit the city centre leisurely might not unless they have a one-off subscription.	No

Code	Workplace Commute (pre-pandemic	Driving Licence	Car Status	Potential for MaaS with CAZ and Traffic Cells Initiative	Works in Birmingham City Centre
P23	Train	Yes	Access to someone else's	Great solution to find all available transport modes in one app, however the subscription cost needs to be reasonable. People who are new to the city can benefit from the service.	Don't know
P24	Drive	Yes	Own	The importance of MaaS would be increased with the CAZ and Traffic Cells Initiative. The demand for public transport is anticipated to increase and therefore MaaS could suggest particular modes of travel that are less busy.	No
P25	Train	Yes	Own	People would be made to think twice if they need to drive and perhaps MaaS could help car drivers navigate public transport better.	No
P26	Drive	Yes	Own	MaaS would be more appealing in light of travel restrictions into the city centre by personal car.	Don't know
P27	Drive	Yes	Own	MaaS would be appealing because it would be less than £8 per day to pay for MaaS.	No