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Sustainable travel behaviours of TOD residents:

An examination of TOD residents' travel mode choices and consistency in Hangzhou

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Being a dissertation submitted to the faculty of The Built Environment as part of the requirements for the award of the MSc Transport and city planning at University College London:

I declare that this dissertation is entirely my own work and that ideas, data and images, as well as direct quotations, drawn from elsewhere are identified and referenced.

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Abstract

Transit-oriented development (TOD) is an urban design model designed to attract more sustainable travellers. However, not every TOD project conducts a highly sustainable travel sharing rate, and the proportion of daily car users in TODs is still growing steadily each year, especially in the cases of Chinese cities. Meanwhile, many Chinese cities are putting enormous investments into metro infrastructure development, but they are uncertain of whether these resources could be adequately used. Therefore, using the data collected from 1,298 TOD residents in Hangzhou, this paper aims to examine the wider impacts of TODs on the residents' travel behaviours to broaden the current studies of travel behaviours by using the perspective of TOD residents and examining travel behaviour consistency. More specifically, this research employs three binary logistic models to identify the key variables which determine TOD residents' travel choices and mode consistency. The results demonstrate that variables like monthly income, residential tenure, workplace metro accessibility and travel attitudes significantly impact travel mode choice, while variables like monthly incomes, the number of children in a household and increased car number influence the sustainable traveller's behavioural consistency. A limited number of factors can influence car users to shift to sustainable travel behaviours. The research results would eventually contribute to planners' design theories on TOD and implementation of new policies to reach a higher sustainable transport sharing rate within TOD properties as well as an adequate use of the metro infrastructure investments.

1. Introduction

Transit-oriented development (TOD) is not a new planning theory but has been advertised widely in the last decades as a response to the worldwide trend of sustainability. Meanwhile, with the expansion of cities and the growth of urban populations, the proportion of travels made by private vehicle owners has increased annually, especially in Chinese cities which are still growing rapidly. TOD has become more prominent as a sustainable solution not only as a result of traffic congestion and car emission, but also because of energy depletion, traffic casualties, global warming, obesity and health impacts of inactivity, and the loss of street space to the car, which are sustainability issues caused by motorisation (Schnohr et al., 2006). Since people are seeing the success of several TOD projects that display a low percentage of car usage and increased daily rail-dependent travel behaviours, such as Ørestad in Copenhagen (Fullerton & Knowles, 1991), TOD is viewed as an urban design model for development around transit stations and as a means of coping with the sustainability issues addressed previously (Arrington and Cervero, 2008; Litman, 2015; Vale, 2015), including in China (Energy Foundation China, 2014).

The key reason that TOD projects require low car dependency is that it requires public transport to exist near the residences; it also requires a mixed land use enabling people to walk to home, work and leisure sites (De Vos et al., 2014). The characteristics of TOD's internal design also impacts residents' travel behaviours by increasing their opportunities to walk and bike to destinations and creating more vibrant surroundings (Zhao & Li, 2017; Akbari et al., 2018; De Vos, 2020). However, not every TOD project produces a high sustainable travel sharing rate, although most of them are significantly above the city average. Despite TOD implementation, the number of daily car users is still growing steadily each year, especially in the cases of Chinese cities. Moreover, many Chinese cities have expanded their metro infrastructures in recent years and have set up several new TOD projects along with the metro expansion. With the new population moving in the new TOD projects could create pressure within the local traffic systems and trigger serious sustainability issues if the residence within the metro station catchment area cannot maintain sustainable travel behaviours.

Many studies have been conducted to identify the variables which influence individuals' travel choices; researchers have examined built environments, travel attitudes and socio-demographics (Gehlert et al., 2013). In studying built environment, researchers have proven that urban structure density and mixed land use (Hickman & Banister, 2005; Zhang & Zhao, 2017), distance to local services and work (Vu & Ohnmacht, 2019), movement framework (Williams & Dair, 2007) and local walking and cycling infrastructures (Lin et al., 2018) relate to travel behaviours. Some have also argued that a pro-public transport attitude is a key factor in increasing individuals' motivation to use sustainable transport (Naess, 2005; Cao et al., 2009; Susilo & Dijst, 2009; Susilo & Waygood, 2012) and have also argued that the association between this factor and their desired travel behaviours exists in children's minds (Marzoughi, 2011). Researchers have also universally examined socio-demographic variables, including age, gender, income, car ownership, housing ownership, education, employment and family size etc. (Lund et al., 2004; Olaru et al., 2011; De Vos et al., 2012; Chen et al., 2017; Zhao & Li, 2017; Cheng et al., 2019). However, few studies specifically examine the characteristics of TOD residents to help determine higher resource efficiency for metro developments. The number of studies which examine the consistency of individuals' travel behaviours after a period is even limited.

To fill these research gaps, this paper aims to examine the wider impacts of TOD projects on residents' travel behaviours by using Hangzhou as a case study. This research employs binary logistic regression models to answer the following two questions: (1) What key variables, covering socio-economic demographics, built environments and attitudes determine TOD residents' travel behaviours? (2) How do individuals' travel behaviours change after a period as a consequence of different life routines and a shift in their built environment? The research results of this dissertation could broaden current studies on travel behaviours by utilizing the perspectives of TOD residents and examining the consistency of their travel behaviour. Additionally, after an understanding of the determining variables of TOD residents' travel behaviours choices and consistency is established in this paper, the results will contribute to planners' design theories on TOD and new policy implementation designed to aid in reaching a higher sustainable transport sharing rate based on metro systems.

The remainder of this paper is organised as follows: Section 2 reviews the concepts of TOD and the importance of sustainable travel behaviours. It also critically investigates the possible variables that could impact travel behaviours, choices and consistency in individuals' life routines. A brief background of Hangzhou's city context is presented in Section 3. Section 4 illustrates the data and methodology used for this case study. Section 5 presents and discusses the model results. Finally, the paper ends with a summary of the key findings and policy implications in Section 6.

2. Literature review

2.1 TOD and Metro planning theory

Transit-oriented development (TOD) planning theory utilises space around both new and existing transport stations and combines the building of private housing, commercial units and public services. This theory focusses on providing TOD residents efficient, reliable and advanced rail services which connect every part of the city (Cervero, 1996; Renne, 2016). Loo et al. (2010) explain that TODs can be identified by their compact layouts and mixed land use. TOD aims to address suburbanisation, which can be defined as the movement of people from cities into suburban areas, which began in the 1950s and has caused areas outside of cities to expand and grow much faster than inner-city zones have (Biau, 2001). As a consequence, car usage and travel distances have increased dramatically (Gordon et al., 1989), and people are increasingly dependent on car usage for both work and leisure. TOD can present itself in several forms, including high-density TOD, new TOD and low-density TOD (De Vos et al., 2014). The type of new TOD is commonly seen in European cities as new city development projects are generally constructed outside of city centres, whereas high-density TOD is adopted to deliver compact urban developments within existing regions in many Asian cities.

TOD has several characteristics which prevent urban sprawl and reduce car dependency: its high density encourages the use of public transport; its design creates proximity between public transport and local residences, employment and retail destinations; and its mixed land use enables people to walk to home, work and leisure sites (De Vos et al., 2014). Therefore, TOD tends to reduce car use and urban sprawl by two means: the increase in public transport access and the promotion of density. As TOD enables easier access to public transport, it likely impacts residents' dependence on private car usage, and having densely populated construction allows residents to reach most of their daily activities on foot. However, when implementing TOD, developers must be aware that the quality of public transport must be high to ensure residents are more open to using it. Developers should consider the frequency and speed of public transport, the public transport nodes connectivity, and its capacity and comfort in comparison to a private car. The decrease in car dependency would ultimately

change the overarching urban structure from urban sprawl to a more concentrated structure by limiting expansion and damage to the natural environment.

Travel behaviour is also impacted by TOD's internal design, which creates more opportunities to walk and bike to destinations and more vibrant surroundings (De Vos, 2020). In a TOD site, car driving and parking are restricted, but walking and cycling are actively encouraged as possible travel modes for internal short trips. Zhao and Li (2017) also state that walking and cycling are the "last mile modes" which play an important role in promoting residents' public transit usage; this means that TOD should implement better walking access to and from transport stations to reach its fullest potential (Akbari et al., 2018). A complete bicycle network in TODs will also create a symbiotic relationship with public transport (Kager et al., 2016). Lee et al. (2016) found that cycling would extend the accessible commuting area by 25 times in comparison to the accessible area only by walking, which would make transport stations even more accessible. "Bicycle + transit" as a form of commuting has consequently been identified as an essential way to reduce the use of private cars and increase public transport access (Zhao & Li, 2017, p.47).

2.2 Sustainable travel behaviours

Sustainable travel behaviours consist of the daily usage of either public transport or active transport as opposed to private car usage. The global environmental crisis and population booms have facilitated the encouragement to utilise sustainable travel behaviour internationally, especially in metropolitan cities and their buffering areas (Ben-Elia & Shiftan, 2013). According to the United Nations (2012), there will be a global population expansion of 2.3 billion people in 40 years, but urban population growth will increase that number to 2.7 billion. Although a connective transport system is the foundation of a city's employment and economic activities, especially in promoting its market's competitiveness, its damage to the environment, including CO_2 emissions, air quality decline and noise, becomes more significant. The European Commission (2011) stated that urban mobility accounts for 40 % of all CO_2 emissions of road transport and up to 70% of other pollutants from transport. Despite the rise in awareness concerning alternative travel methods, private cars are still the major choice for mode of transport due to their flexibility, privacy and comfort. Additionally, private car

use is not only popular in developed countries private car ownership has also dramatically increased in developing countries, particularly in India, Latin America and China (Dargay & Gately, 2010).

Car emissions are not the only issue that must urgently be addressed by shifting to more sustainable travel behaviour. For example, Schnohr et al. (2006) found that growing daily car use in Western countries has caused the consequential health degradation of the people living in those countries. Several identical issues have been outlined in literature and institutions' reports as the result of mass motorisation, including energy depletion, carbon dioxide emissions, traffic casualties, decreased local air quality, obesity and other health impacts of inactivity, and the loss of street space to the car. For instance, the WHO (2015) reported that approximately 1.25 million people were killed by traffic accidents, which means that traffic accidents caused about 3,400 deaths every day; traffic accidents are also the top cause of death among young people (15-29); moreover, pedestrians, cyclists and motorcyclists account for half of the deaths that occur. Although a significant number of people only sustain non-fatal injuries during such accidents, these injuries often permanently affect them or disable them. In terms of obesity and health impacts of inactivity, researchers (OECD, 2013) have found that the rise of obesity and non-communicable diseases (NCDs) strongly associated with individuals' travel behaviours and built environment, which means the individuals with high motor usage would have a higher chance to get obesity and facilitate NCDs such as cardiovascular diseases and diabetes.

As a result, the role that cars play in travel and the promotion of sustainable travel behaviours must be reconsidered. Transport should not only facilitate fast connections between points but should also support an individual's well-being, social equality, environment, as well as an attractive city design and the economy. Specific planning strategies and policies should be considered to advertise sustainable mobility and impact citizens' travel behaviours and their participation in society.

2.3 Key determinants of travel behaviours

Many authors have discussed the psychology of travel behaviours to explain how users act and react in the transport system. The common agreement is that the interaction of both internal and external factors determines someone's travel mode. Gehlert et al. (2013) summarised a framework of hierarchy decisions which indicates that the external factors can largely impact travellers' potential decisions, but personal factors determine their actual travel behaviours at the final stage. The framework takes every functional step that can influence behaviours, from planning to travel to actually travelling, into consideration.

2.3.1 Built environment

Within the decision-making process of an individual's travel behaviours, how the built environment influences the mode choice is a popular research topic. The impacts that different urban forms can have on specific indices of activities and travel choice have been widely examined. The consensus is that promoting city density and enhancing the mixed-use of land could reduce people's dependence on cars, as a dense urban structure would maximise the efficacy of public transport services and facilitate more walking and cycling travels (Hickman & Banister, 2005). The theory has been proven in the case of Beijing. Zhang and Zhao (2017) concluded that mixed-land-use policies reduce transport energy consumption and found that walking and cycling can cover 30% of all travel in communities that maintain a strong employment-housing balance. A study conducted by Swiss National Travel Surveys which compiled data for 2010 and 2015 also concluded that high residential and employment densities, close proximities to interest spots (parks, sports facilities, etc.), accessible public transport services and sufficient local recreation can reduce daily car travels (Vu & Ohnmacht, 2019).

The movement framework may also be able to limit car travels (Department of the Environment Transport and the Regions, 1998). An appropriate movement framework should include an integrated transport network and provide pedestrians and cyclists with "dedicated, convenient, direct" routes by avoiding cul-de-sac configuration. The supply of public transport and the direct connection to interchanges are also important (Williams & Dair, 2007). Moreover, the quality of built environment is also associated with the usage of public bikes.

Apart from factors like the directness of travel routes, travel distance and road network density, other built environments which include road intersections, road length and arterial intersections relate to public bike usage as well (Lin et al., 2018). However, some authors also found that a built environment's association with public bike usage is not transferable among transnational cities and that collecting local empirical knowledge on travel behaviour is critical for developing bike-friendly built environments in a city.

Whilst many studies support that certain built environment will encourage sustainable travel behaviours, some researchers have uncovered non-correlative results. They argued that "compact cities" with high densities which promote walking, cycling and public transport may not be able to reduce car usage and attract sustainable travellers from regional and intra-regional levels. For example, during a study of Charlotte, US, Yasukochi (2007) found that household income was strongly associated with subjects' travel emissions, but built-environment factors, including accessibility to jobs and shops, weakly influenced the same. During Susilo et al.'s (2012) study of 13 new neighbourhoods in the UK, they discovered that higher incidences of walking in denser, mixed and more permeable developments were not found, nor did residents of those neighbourhoods own fewer cars than the population as a whole. However, they did prove that some neighbourhood design elements cause more sustainable travels. In the case of Beijing, China, researchers also found land use may have little impact on attracting people living within the area where a metro station is located, while income and housing prices are the most prominent determining factors (Zhao & Li, 2018). In addition, Williams et al. (2000) argued that multi-centred or corridor developments could be another urban structure which encourages sustainable transport.

2.3.2 Attitude

Attitudes and preferences have been widely acknowledged as the variables which impact travel behaviours over an extended period. Research which was conducted by De Vos and Witlox (2016) reveals that if individuals are not restricted by any element like a built environment, they will more frequently use the mode which they prefer. Although attitude factors are usually treated as control variables, many researchers have also worked on attitude factors and have found a significant association with travel behaviours (Cao et al., 2009; Naess, 2005). As mentioned previously, individual attitudes are more associated with

travel modes which relate to built environment factors such as increasing a city's density (Susilo & Dijst, 2009; Susilo & Waygood, 2012). This indicates that if individuals' attitudes are not changed, urban design policies are less likely to gain actual effect. Moreover, the attitudes towards travel behaviours are relevant to long-term sustainability education and changing future generations' lifestyles. Marzoughi (2011) studied the growing trend of chauffeuring children by car and noted that this trend associates with a decreasing number of active travels being made by children and adolescents. However, again, the results from Susilo et al.'s (2012) study of 13 new neighbourhood developments in the UK illustrates a different outcome. Most of the interviewees discussed their care for environmental sustainability, but their travel behaviours were not consistent with their attitudes. Susilo et al. (2012) concluded that individuals' attitudes strongly influence their decision to walk within their neighbourhood, but do not strongly influence their choice to cycle or use public transport.

Another attitude-related factor is emotional well-being. According to the broaden-and-build theory of positive emotions, commute happiness can positively affect individual and societal well-being (Cohn et al., 2009). More importantly, improving how sustainable transport affects commute happiness would also attract more sustainable travellers. From current studies, public transport travellers have a lower average happiness level than private car users do (Cloutier et al., 2014; St- Louis et al., 2014; Lancée et al., 2017) and car travellers' happiness levels increase when travel time gaps with public transport users' are more significant, as they gain the feeling superiority (Abou-Zeid & Ben-Akiva, 2011). Zhu and Fan's (2018) research on travel happiness in Xi'an demonstrates that commute happiness is largely determined by travel mode and duration over frequency in China; they found that employer shuttle buses are the most pleasant travel mode at present in China, and regular city buses are the least pleasant travel mode.

2.3.3 Socio-demographic

Socio-demographic information consists of the universal aspects considered by many travel behaviour researchers as the different ways in which human characteristics could impact travel mode choices. It is also essential to identify the characterised groups which are most influenced based on different research focuses. In some cases, some characteristics are selected as controls to clarify the underlying relationships (Zhao & Zhang, 2018). Common

socio-demographic data in travel behaviour research includes age, gender, income, car ownership, housing ownership, education, employment and family size (De Vos et al., 2012; Zhao & Li, 2017). Many of them have been specifically studied as significant variables which affect people's travel behaviours. For example, a study based in 2013 Nanjing, China, focused on age differences and revealed that living environments and locations impact elderly people's travel behaviours more than younger adults' travel behaviours (Cheng et al., 2019); in terms of income, the literature demonstrates that low-income groups are more likely to live closer to public transport stations (Lund et al., 2004; Olaru et al., 2011; Chen et al., 2017) and walk to access facilities (Lund, 2006). A study on the shift in travel behaviour after the economic crisis in Greece also proved that people use more public transport and motorbikes or favour walking and cycling over using private cars to cut down their expenses after their income drops (Lee, 2010; Ulfarsson et al., 2015; Papagiannakis et al. 2018). The role of human characteristics is more important when it relates to the study of life routines and time-shifting, as many of the shifts in travel behaviour result from changes in socio-demographic features.

2.3.4 Life routine and time gap

A life routine is the change of one's internal and external features after a period of time, which covers changes in human characteristics, social roles, built environments, attitudes, etc. Some typical life routine factors include marriage, the birth of children, job changes, retirement and housing purchases (Prillwitz et al., 2006; Oakil, 2016). These life routine factors could facilitate individual and household structural transitions which influence travel demands and trigger changes in travel behaviours (Zhao & Zhang, 2018).

However, most researchers who study life routine changes mainly focus on residential relocation as a key element and do not track individuals' travel behaviour changes over time and test them against possible life routine factors. The case studies which were conducted in Hamburg (Bruns & Matthes, 2019) and Belgium (De Vos et al., 2018) illustrate that residential relocation is an important factor in life routines; location choice is largely impacted by travel attitudes and also shapes residents' travel attitudes and travel modes. The analysis of household travel survey (HTS) data from the Seoul Metropolitan Area (SMA) is more relevant to time gap as it also covered data which was compiled over an extended period (2002, 2006 and 2010) (Lee et al., 2012). The SMA study examined travel behaviour changes in time and

space and found low-income groups' trip frequency and distance sharply decreased during peak hours, but elderly people's trip duration increased. This research did not take travel behaviours related to mode changes into consideration. Lastly, Zhao and Zhang's (2018) work on travel behaviour and life course study based on residential relocation in Beijing study is most consistent with this paper's objectives. The researchers found that "the birth of kids, marriage, and a larger household size encourage car purchase and facilitate car use" and significantly influence individuals' travel modes after residential relocation. However, the conclusions were drawn based on the horizontal comparison of relocated residences' features instead of the vertical tracking of individuals' behaviour changes.

2.4 Summary

Sustainable travel behaviours have been greatly focussed on in recent literature in comparison to private car travels. Emissions are not the only issue; public concerns related to well-being, social equality, the environment, city design and the economy must also be considered when forming specific planning strategies and policies to advertise sustainable mobility and impact on citizens' travel behaviours. This paper specifically examines the TODs within the metro station buffering area because TOD theories have existed for decades and there are a sufficient number of successful examples of using TOD to reduce car use and stop urban sprawl. It is also important to understand the different types of TOD development, including new TODs, which are new developments outside the city centres, and high-density TODs, which create compact urban developments within the existing regions.

In terms of the factors influencing people's travel behaviours, many researchers have studied them from the built environment, attitude and socio-demographic perspectives to determine the most significant factors which can encourage sustainable travel. Mixed land use, high density and personal preference are all consensus features of high sustainable travel rates. Some researchers have discovered opposing results in their studies. However, little understanding exists regarding whether TOD residents' travel behaviour characteristics differ from non-TOD residents and how individuals shift their travel behaviours over time.

To fill these research gaps, this paper aims to examine the wider impacts of TOD projects on residents' travel behaviours, by determining key variables that influence the travel choices of TOD residents and their individuals' behaviour consistency. All the built environment, attitude, socio-demographic and life routine features should be considered; By observing the factors which encourage TOD residents to give up public transport or turn to public transport would provide guidance for planners and policymakers towards a pro-sustainable-travel society.

3. City context

Hangzhou is the capital city of Zhejiang, which is a province in China that possesses a population of 10.36 million people. Hangzhou does not have a long metro history since its first line opened in 2012. Its network has been expanding rapidly since then, and five lines are now open and cover 206.18 km running distance and connect 133 stations. The city's network plan and metro construction were accelerated after Hangzhou was officially appointed as the host city of The 2022 Asian Games. By 2022, it aims to have 11 underground lines in operation and four interurban railways. The city has also suffered from severe car congestion for decades. In 2012, when Hangzhou was experiencing its worst road traffic conditions, the city was ranked as one of the top three most congested cities in China. As a result, the Hangzhou Traffic Police Department (functions similarly to TfL in London) organised a congestion-solving team and adopted engineering measures to improve infrastructure and reorganise traffic flows for better use of road resources, including the set-up of BRT bus lanes, reversible tide lanes and large block one-way traffic circles. Political measures were also added to ease congestion: in 2014, the issuing of new car licenses began to be significantly restricted (from 120,000 private car licenses being issued annually to 20,000), and every private car is banned from entering congestion during peak traffic hour once a week. Working together with the increasing accessible rides available through the metros, Hangzhou decreased its congestion rank from 3rd to 45th in 2018. However, congestion is still critical all over the city, and air pollution, safety issues and health issues cannot be avoided without a higher sharing rate of sustainable travel. Additionally, green energy cars are exempt from licensing restrictions and peak-hour entry restrictions in Hangzhou due to the government's support of the electric vehicle industry, which has led to a tide of new electrical vehicle purchases being made and a new increase in car ownership. Another outstanding issue of Hangzhou's transport system concerns its metro construction which was pushed way ahead of the previous metro plan due to The 2022 Asian Games. That could lead to a waste of infrastructure investment if the metro travel proportions stay low. Meanwhile, many new TOD projects have been implemented, including enormous residential areas being constructed around future metro stations. If the residences within the metro station catchment area cannot adopt and maintain sustainable travel behaviours, tens of thousands of private cars could flood into the precarious road traffic system in Hangzhou City Centre, which could cause enormous transport issues.

4. Data and methodology

4.1 Site selection

Due to the limited research time, this study adopted a case-control sampling method to examine the randomised experimental designs of every metro station in Hangzhou. Although Hangzhou did not utilise some strict TOD site designs during its first phase of metro development, the sample frame still consisted of two populated metro stations: Ding'an Road Station and Qibao Station, which are both surrounded by dense residences and mixed land use. However, these factors fall under different TOD types. Both stations belong to the earliest group of stations on Hangzhou's first Metro Line 1, which opened in 2012. Ding'an Road Station is a high-density TOD which exemplifies a compact development in an existing old residential district; Qibao station is a new TOD outside the former city centre and is a completely new construction (see **Fig. 1**). Ding'an Road Station is surrounded by new office buildings, restaurants and a large shopping mall, which are all located within a 300m radial buffering area around the station. Qibao Station is more diverse in function; it features a rail depot for Hangzhou Metro on the ground level.

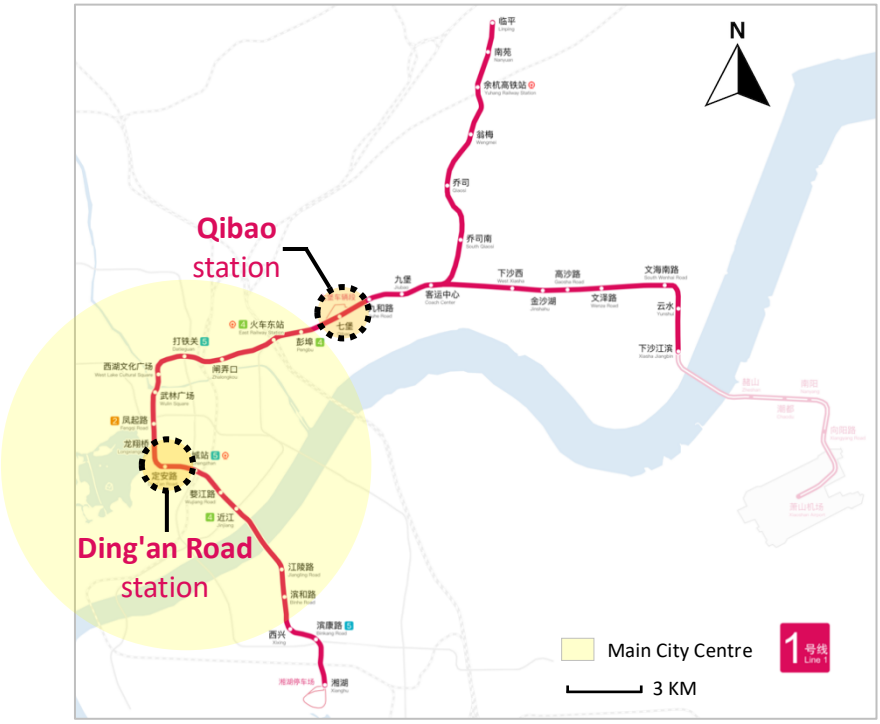


Fig. 1 Sites map of Hangzhou

4.2 Data collection

This study used an online questionnaire to collect data due to the coronavirus (COVID- 19) pandemic and the restrictions it placed on travel and in-person interactions. This method ensured that sufficient samples would be collected for the quantitative data analysis which would be made via regression models. A total of 1,298 valid responses were received; 597 samples related to Ding'an Road Station and 701 samples related to Qibao Station. The questionnaire also gathered data on individuals' travel behaviours, socio-demographics, built environments, attitudes and opinions, as well as information from five years earlier (2015), to study respondents' behavioural changes. To collect data from the residents who live within each studied area, the online questionnaire was distributed to local communities' social media group chats (WeChat) via weblinks during July 2020. The major concern related to the data collection was that elders' groups might be left out of the investigation as every questionnaire needed to be completed online due to the extenuating circumstances. However, the response was adequate: 194 respondents who live near Ding'an Road Station and 31 respondents who live near Qibao Station were over 55 (**Table 1**). Although the population structures were significantly different based on the two developments' characteristics, the elders' data was sufficient for the regression analysis.

Table 1 Population age range and sample size of two sites

	Ding'an Road station		Qibao station	
Age range	Sample size (n=597)	Percentage	Sample size (n=701)	Percentage
18-25	77	12.9%	80	11.4%
26-30	76	12.7%	178	25.4%
31-35	76	12.7%	205	29.2%
36-45	79	13.2%	138	19.7%
46-55	95	15.9%	63	9%
56-65	131	21.9%	30	4.3%
Over 65	63	10.6%	7	1%

4.2.1 travel behaviours

The data related to travel behaviour were collected by asking respondents what they use as daily major commuting modes in 2020 and 2015. If they choose between private cars and the metro, they would be asked to answer an additional question which investigated their major reasons for choosing that mode of transport. The respondents could select up to three items

from the list of potential reasons. Additional information about their travel behaviour during weekends and their main purposes for making these travels was also acquired at the end of the questionnaire. Detailed choice options can be found in Appendix 1.

4.2.2 Scio-demographics

The study captured a list of socio-demographic data that may impact individuals' travel behaviours. This study asked respondents to provide data on genders, age ranges, highest education qualifications, marriage statuses, monthly incomes, household sizes, the number of children under 18, residential tenure (renter or owner), car ownership, driver's license statutes, work distance ranges and workplace metro accessibility. The respondents were asked to provide information concerning the same factors in 2015 as well.

4.2.3 Built environment and travel-related attitudes

In terms of built environments, the questionnaire investigated whether respondents' neighbourhoods have pleasant a walking environment, cycling environment and convenient access to the metro stations. The respondents were again asked to provide data about the same factors in 2015. Although both sites are compactly mixed-used, the questionnaire still considered what services were missing according to the residents' opinions for the analysis and the regression modelling. For the same purpose, respondents were able to choose "I do not know" over "Yes/No" so that the author could study the pro-metro or pro-car travel-related attitudes as another essential factor since they have been proven significant by researchers who were mentioned in the literature review.

4.3 Methodology

A binary logistic regression was applied as the key methodology since it was the most appropriate analysis approach and can reveal the underlying relationship (Hosmer & Lemeshow, 2004) between such variables that relate to the probability of using cars over sustainable transport, as well as shifting to using cars from sustainable travel behaviours after a certain period. Moreover, a similar methodology has been used for many other studies of travel behaviours (Chen et al., 2017; Cheng et al., 2019). This study established three binary logistic regressions. The estimated equations are illustrated below:

$$P(Y = 1|x_1, x_2, \ldots, x_m) = \frac{e^{(\beta_0 + \sum \beta_i x_i)}}{1 + e^{(\beta_0 + \sum \beta_i x_i)}} \quad (1)$$

$$\text{logit } P(Y = 1|x_1, x_2, \ldots, x_m) = \ln\left(\frac{P}{1-P}\right) = \beta_0 + \beta_1 x_1 + \ldots + \beta_m x_m \quad (2)$$

The dependent variable *Y* has a binary value (0 or 1), and P(*x*) stands for the probability of *y* = 1 given the value of *x*. The variable *x* represents the vectors of independent variables and β_0 is a constant, and the parameters βi (*i* = 1, 2, ..., *m*) are the coefficients of each *x* which reveal the possible impact of each independent variable exerted on the dependent variable (Menard, 2012). To measure the model fit statutes, an adjusted R2 > 0.2 and a Hosmer and Lemeshow Test usually represents a sufficient logistic regression outcome (Li et al., 2013; Shu et al., 2014).

4.3.1 Dependent and independent variables

As the dependent variable could only be a binary value (0 or 1), data on various travel behaviours collected through the questionnaire were transformed in two categories: sustainable travels (metro services, buses, cycling and walking) were coded as 0 and car travels (private cars and taxis) were coded as 1. Although this means missing of specific types of transport information during the regression analysis, a descriptive statistics analysis was also included in this research to distinguish the data on travel behaviours by each mode. Similarly, several independent variables were also recoded into a binary value, including marriage, residential tenure, attitude and TOD sites. The first regression model was used to study the variables which impact the possibility of using car travel rather than sustainable travelling options, so present sustainable travel samples were coded as *Y* = 0, and present car travel samples were coded as *Y* = 1. The following two binary logistic regressions were conducted. One was used to study the variables which impact the possibility of shifting to car travel instead of using sustainable travel options for those who used sustainable travel options five years ago (*n* = 1,012); *Y* = 0 if present travel behaviours remained sustainable, and *Y* = 1 if the behaviour changed to using cars. The other logistic regression was used to study the variables which impact the possibility of shifting to sustainable travel options instead of using cars travel for those who used cars five years ago (*n* = 264); *Y* = 0 if present travel behaviours remained consistent and *Y* = 1 if they changed to using sustainable travel

options. For the independent variables, several additional variables were produced by calculating the gaps between same factors in different times, such as increased income, changes in the number of children in a household, working distance changes, environmental changes, etc. These calculated gaps were also processed into binary values for a better fit with the models. The final independent variables are summarised in **Table 2**.

Table 2 Description of the variables

Categories	Variables (in 2020)	Description
Socio-demographics	Gender	0 = Female; 1= Male
	Age	1 = 18-25; 2 = 25-30; 3 = 30-35; 4 = 35-45; 5 = 45-50; 6 = 55-65; 7 = 65+
	Education	1 = Mid school and below; 2 = High school, 3 = College & Undergraduate; 4 = Postgraduate & above
	Marriage statuses	0 = Single; 1 = Married
	Monthly Incomes	1 = ¥ 2,000-3,000; 2= ¥ 3,000-5,000; 3 = ¥ 5,000-10,000; 4 = ¥ 10,000-15,000; 5 = ¥ 15,000-20,000; 6= ¥ 20,000+
	Household sizes	Number of household members
	Children	0 = No child; 1 = Have a child/ children
	Residential tenure	0 = Owner; 1= Renter
	Car ownership	Number of motor vehicles available in the household
	Driving licence	0 = No licence; 1 = Have licence
Built environment	Working distance	1 = < 1 km; 2 = 1-5 km; 3 = 5-10 km; 4 = 10-20 km; 5 = 20 km +
	Workplace metro accessibility	0 = Not accessible; 1 = Accessible
	Pleasant walking environment	0 = No; 1 = Yes
	Pleasant cycling environment	0 = No; 1 = Yes
	Convenient access to the metro stations	0 = No; 1 = Yes
	Site	0 = Ding'an Road station; 1 = Qibao station

Attitudes	Travel-related attitudes	0 = Pro Metro; 1 = Pro Car
Computed Variables	Monthly Income increase (from 2015 to 2020)	Dummy variable (minus stands for decrease)
	Household sizes increase (from 2015 to 2020)	Number of increased household members (minus stands for decrease)
	Children number increase (from 2015 to 2020)	Number of increased children under 18 (minus stands for decrease)
	Car ownership increase (from 2015 to 2020)	Number of increased motor vehicles available in the household (minus stands for decrease)
	Driving licence changes (from 2015 to 2020)	0 = No change; 1 = Obtained a driver's license
	Working distance increase (from 2015 to 2020)	Dummy variable (minus stands for decrease)
	Workplace metro accessibility changes (from 2015 to 2020)	0 = No change; 1 = Got new metro access to workplace
	Walking environment changes (from 2015 to 2020)	0 = No change; 1 = Got improved walking environment
	Cycling environment changes (from 2015 to 2020)	0 = No change; 1 = Got improved cycling environment
	Access to the metro stations changes (from 2015 to 2020)	0 = No change; 1 = Got improved access to the metro stations

(2020), (2015) stand for responders' answers to the same variables in different years.

5. Results and discussion

5.1 Descriptive statistics

The age distribution of each site is presented in **Table 1**. It is easy to notice that t more elderly residents live near Ding'an Road Station. In contrast, residents between the ages of 25 and 45 occupy more than 75% of the population around Qibao Station. This difference exists because Ding'an Road Station is a TOD based on existing old residences which have been there for over 20 years and form relatively aged and changeless communities; in comparison, the Qibao Station area has existed for under 10 years. A similar conclusion can be drawn from residential tenure differences between the two sites (**Table 3**): the owner proportion is 10% higher around Qibao Station. One should also note that new TOD projects are more attractive to younger generations because they feature better architectural quality and greener infrastructure but are more removed from city centres. The average number of family members in each household was about three people (3.3) for Ding'an Road Station and four people (3.8) for Qibao Station. Moreover, the number of families who have two children was significantly higher for Qibao Station than it was for Ding'an Road Station (27.1% and 12.7%). This could be impacted by the difference between the two properties' average house sizes and structural ages combined with the two-child policy, which was implemented in 2015 in China. Regarding the differences in income, residents who lived in the Qibao Station area had higher average salaries (¥ 5,000-10,000 per month) than residents who lived in the Ding'an Road Station area (¥ 3,000-5,000 per month), which may potentially be determined by the housing price gap between the two sites.

In addition to the built environment factors, the two sites have surprisingly high and consistent results (**Table 3**). For both sites, around 84% of the residents thought that their neighbourhoods provide pleasant walking environments, although the Ding'an Road Station area has an older road network. This positive attitude could be attributed to the redevelopment progress of the TOD project which has significantly bordered the sidewalks, added pedestrians' facilities and green areas and has limited cars' access to the neighbourhoods' lanes. The satisfaction concerning cycling environments was also at a high level, although Qibao Station's satisfaction levels for this factor were slightly lower than

expected. As a new TOD type, Qibao Station's compact development stretches vertically, which positively influences internal communication, but does bother cyclists who need to navigate several floors before they can join the road traffic. However, this more advanced new TOD design does help commuters access metro service more easily via several lifts rather than using the outdoor pedestrian walkways. Consequently, the satisfaction percentage for the access to the metro stations in the Qibao Station area was 3.2% higher than it was for the Ding'an Road Station area, although it is less statistically significant between the two sites (*p*-value = 0.085). Overall, all the built environment variables which were previously discussed have indicated pro-sustainable travel environments are present in both sites, which is consistent with the literature (Renne, 2016; De Vos, 2020).

Table 3 Descriptive statistics and summary test statistics (Chi-square test)

	Ding'an Road station		Qibao station		Chi-square test
Variable	Sample size	Percentage	Sample size	Percentage	p-value
Residential tenure					0.000
owner	478	80.1%	488	69.6%	
renter	119	19.9%	213	30.4%	
Children					0.000
0	170	28.5%	176	25.1%	
1	344	57.6%	322	45.9%	
2	70	11.7%	190	27.1%	
3+	13	2.2%	13	1.3%	
Pleasant walking environment					0.486
Yes	504	84.4%	593	84.6%	
No	55	9.2%	76	10.8	
I do not know	38	6.4%	32	4.6%	
Pleasant cycling environment					0.019
Yes	506	84.8%	566	80.7%	
No	58	9.7%	101	14.4%	
I do not know	33	5.5%	34	4.9%	
Convenient access to the metro stations					0.085
Yes	448	75%	548	78.2%	
No	128	21.4%	126	18%	
I do not know	21	3.5%	27	3.9%	
Weekday travel behaviours (2020)					0.001
Private cars	133	22.3%	206	29.4%	
Metros	283	47.4%	326	46.5%	
Buses	83	13.9%	65	9.3%	
Cycles	66	11.1%	73	10.4%	
Walk	25	4.2%	18	2.6%	
Taxi	7	1.2%	13	1.9%	
Workplace metro accessibility					0.003
Yes	280	46.9%	385	54.9%	

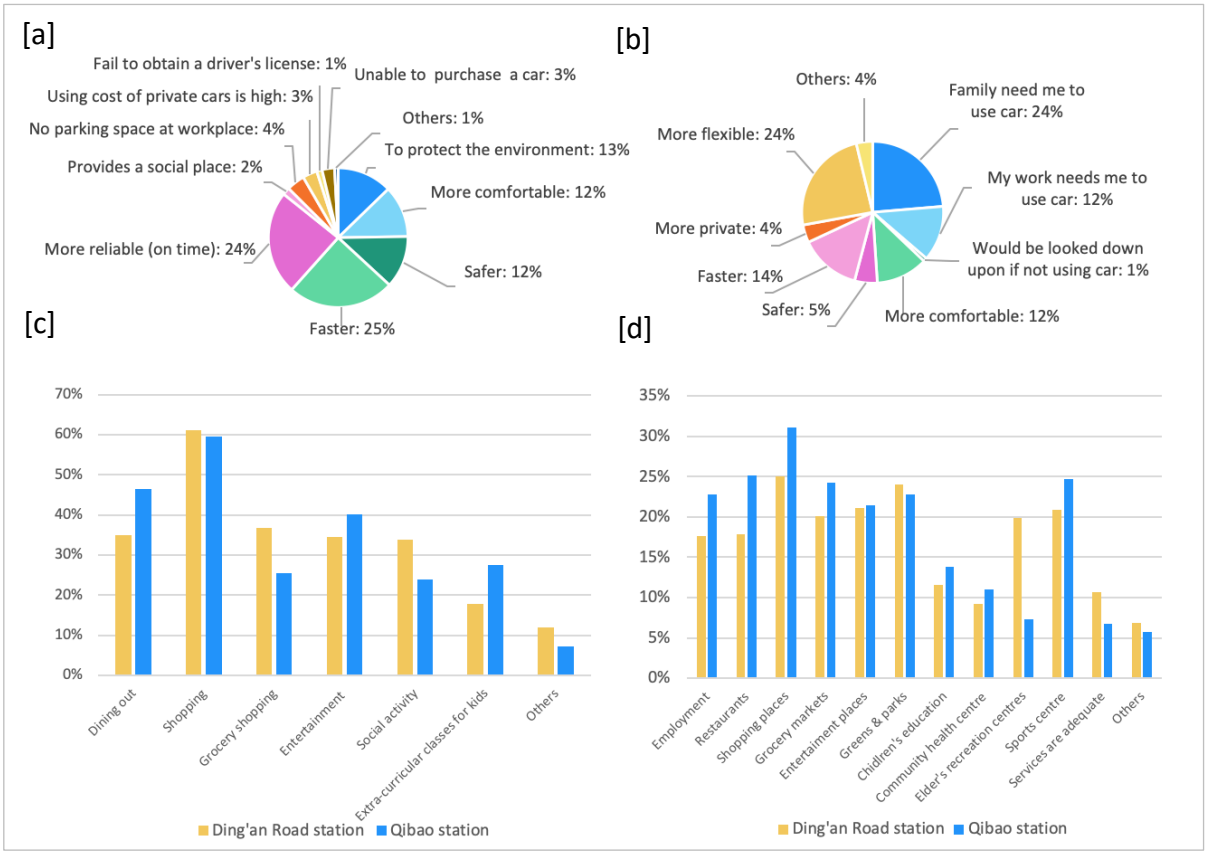
No	208	34.8%	224	32%	
Walking/ cycling only	83	13.9%	76	10.8%	
I do not know	26	4.4%	16	2.3%	
Weekend travel behaviours					0.000
Private cars	163	27.3%	277	39.5%	
Metros	273	45.7%	291	41.5%	
Buses	71	11.9%	53	7.6%	
Cycles	51	8.5%	51	7.3%	
Walk	26	4.4%	20	2.9%	
Taxi	13	2.2%	9	1.3%	
Weekday travel behaviours (2015)					-
Private cars	106	17.8%	146	20.8%	
Metros	179	30%	219	31.2%	
Buses	198	33.3%	219	31.2%	
Cycles	87	14.6%	72	10.3%	
Walk	24	4%	28	3.7%	
Taxi	2	0.3%	19	2.7%	

1. The statistically significant differences compared by Chi-square test were defined by p-value <0.05.
2. (2020), (2015) stand for responders' answers to the same variables in different years.

In terms of residents' travel characteristics, both sites' residents exhibited a relatively high sharing rate of sustainable travel behaviours (see **Table 3**), especially for metro travels, which consisted of approximately 47% for both Ding'an Road Station and Qibao Station. This proves that metro stations can significantly attract metro trips within their buffering areas, especially in cases where built environments are friendly to sustainable travellers. However, the private car sharing rate in Qibao Station's new TOD property was disappointingly high (29.4%) in comparison to Ding'an Road Station (22.3%). Additionally, the private car ownership rate was also higher for residents from the Qibao Station area than it was for residents from the Ding'an Road Station area (79.6% versus 73.4%). The higher average income and a larger number of available parking spaces in new TOD projects could be potential reasons for this difference. Regarding working distances, the results reflect the exact characteristic differences between the two TOD types: a new TOD is a remote site outside the city centre while a high-density TOD is a redevelopment of existing urban districts. The data revealed that the average working distance for Ding'an Road Station residents is 1–5km and Qibao Stations is 5–10km. Finally, workplace metro accessibility was also outlined as the significant difference variable (*p*-value = 0.003) between those two stations' areas. 54.9% of residents' workplaces are accessible via metro service in Qibao Station, which is 8% higher than it was for Ding'an Road Station. This result may be relative to the residents' self-selection factor, which has been tested by many researchers for similar studies (Chen et al., 2017; Zhao & Zhang, 2018). If an individual's workplace is serviced by advanced public transport, it could

impact that resident's choice regarding their house's location, which tends to connect to the same service. Another valuable piece of information is that the metro sharing rate for Ding'an Road Station (47.4%) was even higher than the workplace metro accessibility rate (46.9%), which indicated that a significant number of residents exist who are attracted to the metro service and use it as their major commuting method but need to transfer to other transport afterwards to reach their workplaces.

When looking at changes in travel behaviours over time, it is interesting to note that, even for the TOD residents, private car drivers are less likely to change their travel behaviours to any sustainable travel modes. According to the survey (see **Table 3**), 108 respondents within the Ding'an Road Station area used cars as their main transport method in 2015; 77 drivers continued to do the same in 2020, leading to a 71.3% retention ratio. The situation around the Qibao Station is basically the same. One hundred and thirteen respondents continue to use unsustainable travel modes out of 165 respondents who drove cars in 2015, which represents a 68.5% retention ratio. It is also worth noting that, although the metro sharing rate increased more than 15% in both TOD areas (from 30% to 47.4% in Ding'an Road Station; from 31.2% to 46.5% in Qibao Station), many of the new users transitioned from using other sustainable travel modes such as buses and bicycles. Both sites exhibited a general trend of increased car travel over the last five years (from 18.1% to 23.5% in Ding'an Road Station; from 23.5% to 31.3% in Qibao Station). The increased usage of cars is more prevalent in New TOD type, which, however, are designed completely based on a sustainable transport lifestyle. In addition to the travel behaviour changes, one must also note that, among the questions that enquired about built environment information and metro accessibility, 42.2% of "I do not know" answers were given by the current car drivers, which was significantly higher than the distribution rate of cars (26.1%). This demonstrates that car drivers no longer care about public transport developments and also have little accesses to this sustainable transport information once they switch to private car travel. Thus, it is still urgent to promote sustainable travel behaviours to the population, including new TOD areas, to prevent existing sustainable travellers from shifting to using private vehicles. The in-depth associations between travel behaviours and related variables will be discussed in the binary logistic regression model section.



[a] Reasons for using metros; [b] Reasons for using cars;
[c] Travel purposes during weekends; [d] Lacking services.

Fig. 2 Additional travel information chart

Additional travel information, including the main reasons for choosing private cars and metro transport, weekend travel behaviours, major travel purposes during weekends and residents' opinions of the public facilities around the sites, were also investigated during the study (**Fig. 2**). The most popular reasons for choosing metro transport are its reliability (it is on time) and fast speed (which was represented in 25% of the related answers). Safety, comfort and low-carbon travel were also common motives for using metro services. For private car drivers, the flexibility of private vehicles was the top reason provided (about 24%); the same proportion of respondents used cars to take care of their families, including transporting their children to school. Comfort and high speed were also reasons (about 13%) which were provided for using cars. Additionally, 12% of the people noted that they require private cars for their daily work. In terms of the travel behaviours exhibited during the weekends (**Table 3**), private car usage rose 5% for respondents from the Ding'an Road Station area in comparison to the weekday trends. The gap was even higher for respondents from the Qibao Station area: the number of car users in that area increased 10.1% during the weekends. Additionally, shopping

was identified as the top travel purpose during the weekend by respondents from both sites (see **Fig. 2** [c]). Dining out and entertainment were also identified as popular reasons for weekend travel by respondents from both sites, while grocery shopping was more popular among residents who live around Ding'an Road Station. Taking children to extra-curricular classes was a more common reason for respondents who live around Qibao Station. Although both TODs exhibit diverse land uses, the residents still advised that many services were lacking around the neighbourhoods, including sufficient employment opportunities, available restaurants, shopping malls, etc. Details can be found in **Fig. 2** [d]. One notable feature is that recreation centres for the elderly are especially in demand in high-density TODs, but sports centres are more welcomed in new TOD properties. The additional travel information which was collected not only advised the built environment factors around TODs but also confirmed the attraction ability of metro services during the weekday. Promoting the metro sharing rate during the weekends and holidays could be the next target of sustainable transport studies.

5.2 Binary logistic regression model results

5.2.1 Travel behaviour choices

One binary logistic regression model was employed to determine the key variables which influence TOD residents' choices concerning sustainable travel behaviours and private car use. **Table 4** illustrates how the final logistic model performed. The Nagelkerke R Square was larger than 0.2; the *p*-value of the Hosmer and Lemeshow Test exceeded 0.05, which means that the regression analysis was statistically significant and that the regression equation had a high degree of goodness of fit (Hosmer & Lemeshow, 2004; Li et al., 2013; Shu et al., 2014). In terms of the independent variables, car ownership and driving license statutes were removed from the final regression model because variables entered in a logistic regression model should be independent, which means that they should be without significant collinearity or multicollinearity between each other. Many empirical researchers have studied car ownership as a dependent variable and have explained the socio-demographics and built environment variables (Pan et al., 2009; Zegras, 2010). These variables could have underlying associations to car ownership and impact the regression outcomes because of unexpected collinearities between independent variables (Van Acker & Witlox, 2010). The same approach was used in Chen et al.'s (2017) research of Vehicle-Kilometres-Travelled (TKT) in TOD; they

were also concerned about the multicollinearity effects of car ownership and ran two models, one with car ownership and one without car ownership. Their results illustrated a better model fit and more valuable information for the model which excluded car ownership as a factor. This study also tested both cases, and the final regression model exhibited a significantly higher Hosmer and Lemeshow Test *p*-value; the two R Square values stayed the same.

Table 4 Model evaluation 1

	Model Summary		Hosmer and Lemeshow Test		
	-2 Log likelihood	Nagelkerke R Square	Chi-square	df	Sig.
Binary logistic regression model for individual's travel behaviour	1185.204[a]	0.311	7.018	8	0.535

a. Estimation terminated at iteration number 5 because parameter estimates changed by less than .001.

Table 5 Logistic regression analysis results of TOD residents' travel choices

Independent Variables	**B**	**S.E.**	**Sig.**	**Exp(B)**
Constant	-2.537***	0.600	0.000	0.079
Socio-demographics				
Gender	0.270	0.161	0.093	1.310
Age	-0.248***	0.059	0.000	0.780
Education	0.268**	0.124	0.031	1.308
Marriage statuses	0.181	0.276	0.512	1.199
Monthly Incomes	0.231***	0.068	0.001	1.260
Household sizes	0.169***	0.063	0.008	1.184
Children	0.432*	0.240	0.073	1.540
Residential tenure	-0.758***	0.198	0.000	0.468
Built environment				
Working distance	0.195***	0.066	0.003	1.215
Workplace metro accessibility	-1.073***	0.157	0.000	0.342
Pleasant walking environment	0.156	0.268	0.561	1.169
Pleasant cycling environment	-0.136	0.247	0.581	0.873

Convenient access to the metro stations	-0.649***	0.179	0.000	0.522
Site	0.001	0.161	0.996	1.001
Attitudes	1.825***	0.247	0.000	6.206

Note: * P<0.1; ** P<0.05; *** P<0.01.

Table 5 presents the results of this binary logistic regression analysis. As for the dependent variables, sustainable travel (metro services, buses, cycling and walking) was coded as 0 and car travel (private cars and taxis) was coded as 1. Thus, a positive B value indicated a higher probability of using a car as a weekday travel mode, and a negative B value indicated a higher probability of using sustainable travel methods during weekdays.

Regarding the socio-demographic aspect, **Table 5** illustrates that the older generations of residents within each TOD area were more likely to maintain sustainable travel behaviours than the younger residents were. This result is consistent with the existing travel behaviours observed by researchers in China (Zhang & Zhao, 2017; Cheng et al., 2019). However, researchers in Western countries, such as Susilo et al. (2012), found that younger generations exhibited lower car usage. Cars have not been present in China's history for as long as they have in the Western world, so the elder groups surveyed for this study may be more used to public transport and are less willing to drive a car. Possessing a higher education background also increases the possibility of individuals using private vehicles. However, both Cheng et al. 's (2019) research based in Nanjing, China and Van den Berg et al.'s research (2011) based in Eindhoven in The Netherlands indicated a positive and strong relationship between an individual's educational level and public transit travel frequency. One possible explanation for the existence of this relationship is the difference in education content since sustainability advertising might be lacking in the higher educational institutions in Hangzhou, although Hangzhou and Nanjing, as Chinese cities, should utilise similar educational systems and content. Another difference is that their two studies both examined discretionary travel, but this study specifically focussed on the travel behaviours exhibited during weekdays. Additionally, another shared characteristic of the respondents who were surveyed for this study is that all of them are the residents of TOD properties, so a close metro connection in the neighbourhood could hold more attraction for less-educated respondents. Monthly

income is another commonly studied socio-demographic variable which impacts travel mode choice. This research result aligns with other literature (Schmöcker et al., 2008; Hjorthol et al., 2010): people with higher incomes are less likely to use sustainable travel methods. Even for the residents within the metro catchment area, this association is still significant.

The logistic regression model also demonstrated that if residents rent properties instead of owning them, they are more likely to have sustainable travel behaviours. This behaviour could be caused as they do not have a private parking space, or they are unable to own a local private vehicle that is allowed to entry Hangzhou city centre due to the licensing restrictions and peak-hour entry restriction policies. Household size and children are the final variables to consider. In Susilo et al.'s (2012) study of UK residents' travel behaviours, households with a larger number of family members tended to use more public transport as household members had to share the car more often. Regarding children, couples who had dependent children were identified as the group which was more likely to use a car. In this study's case, however, both household size and having children under 18 were found to encourage the use of private cars. In this study, household size growth's impact on travel behaviour choices was more significant, regardless of whether children were present in a household (p-value = 0.073). One possible explanation for the household size's association is that an increase in the number of family members reduces private car use cost per capita, as it is common to give family members rides to work or school in China, and staying in one car instead of using public transport together also provides a stronger sense of family and privacy. The effect children have mattered less in this case since individual behavioural choices could be the consequence of the high-quality metro services and easy metro access in the TODs, which also provide sufficient comfort, safety and speed; parents may feel less inclined to use a car specifically for their children. Similarly, gender and marital status are also insignificant variables which impact travel choice for the residents within the TOD areas.

Table 5 also illustrates how the built environment and travel attitude variables impact TOD residents' travel behaviour choices. The model demonstrated that, even for the TOD residents, the increase in working distance boosts the possibility of car use, which is consistent with other travel behaviour researchers' findings on wider city scales (Susilo et al., 2012; Cheng et al., 2019). However, if individuals' workplaces are connected to the metro service, they are

more likely to use sustainable transport instead of private vehicles. In terms of the local built environment, walking and cycling environmental qualities have little impact on travel mode choices for residents in TODS; most researchers believe that local environmental quality for pedestrians and cyclists determines travel behaviours significantly (Susilo et al., 2012; Vu & Ohnmacht, 2019). This concept could be explained since most TOD sites have high-quality walking and cycling environments, and negative respondents were indicating certain unpleasant details instead of overall environmental quality. On the contrary, the convenient levels of access to the metro stations vary for each household, and the ones that have better access to the metro stations would have more opportunities to use metro stations. Thus, redesigning the internal pathways and neighbourhood entrances could improve the metro sharing rate within a TOD area. Moreover, this study demonstrates that the difference between the two sites' TOD types has no significant impact on individuals' travel choices. Finally, as most travel behaviour researchers have discovered, a positive association between car use and pro-car attitudes can found using this model; individuals' pro-metro attitudes would increase their opportunities to use sustainable transport than pro-car attitudes would (Susilo et al., 2012; Chen et al., 2017; Cheng et al., 2019).

5.2.2 Travel behaviour changes

Two additional binary logistic regression models were employed to determine the main driving variables which change individuals' travel behaviours in their life routines. These could include marriage, incomes and the birth of a new child. The invested objectives for the first model were the respondents who had sustainable travel behaviours in 2015, and the objectives for the last model were the respondents who used private cars as their weekday transport in 2015. The possible independent variables in these travel behaviour change studies are more complex, including the existing descriptive variables which were used in the previous travel behaviour choice model and the computed variables which indicate internal and external changes over the years, such as monthly income increases and an increase in the number of children in a household. Thus, it is difficult to avoid the underlying collinearity or multicollinearity between each variable by manually deleting several unnecessary factors. This research applied a forward selection (likelihood ratio) data entry approach. The forward selection "chooses a subset of the predictor variables for the final model", and it is "tractable

and gives a good sequence of models" (IBM, n.d.). Stepwise selection method with entry testing based on the significance of the score statistic, and removal testing based on the probability of a likelihood-ratio statistic based on the maximum partial likelihood estimates (IBM, n.d.).

Table 6 illustrates how these two logistic models performed. Both Nagelkerke R Squares were larger than 0.2 and the *p*-values of the Hosmer and Lemeshow Test were over 0.05. Thus, these two binary logistic regression models based on forward selection (likelihood ratio) data entry method still successfully reflected reality. The independent variables selected to be considered in both models were the same and are listed in **Table 7** (entered and not entered), including all of the socio-demographic and attitude variables in previous models, as well as significant built environment variables and every computed variable. Additionally, a positive B value in the model for sustainable transport users' travel behaviour changes represented a higher possibility of switching from sustainable travel behaviours to private car travel usage as the variable increased. A positive B value in the model for private car users' travel behaviour changes indicated that they were more likely to use sustainable transport as a daily commute method when the variable increased.

Table 6 Model evaluation 2

	Model Summary		Hosmer and Lemeshow Test		
	-2 Log likelihood	Cox & Snell R Square	Chi-square	df	Sig.
Binary logistic regression model for sustainable transport users' travel behaviour changes	701.474[b]	0.181	6.354	8	0.608
Binary logistic regression model for private car users' travel behaviour changes	270.502[a]	0.198	1.611	4	0.807

a. Estimation terminated at iteration number 5 because parameter estimates changed by less than .001.
b. Estimation terminated at iteration number 6 because parameter estimates changed by less than .001.

Table 7 Logistic regression analysis results for sustainable transport users' travel behaviour changes

Independent Variables	B	S.E.	Sig.	Exp(B)
Constant	-1.233***	0.431	0.004	0.291
Variables entered				
Age	-0.314***	0.069	0.000	0.731
Monthly Incomes	0.273***	0.081	0.001	1.314
Residential tenure	-0.820***	0.233	0.000	0.441
Workplace metro accessibility	-1.157***	0.211	0.000	0.315
Convenient access to the metro stations	-0.508**	0.226	0.024	0.602
Attitudes	1.599***	0.302	0.000	4.947
Children number increase (computed)	0.417***	0.158	0.009	1.517
Car ownership increase (computed)	0.810***	0.171	0.000	2.248
Variables not entered				
Gender	-	-	-	-
Education	-	-	-	-
Marriage statuses	-	-	-	-
Household sizes	-	-	-	-
Site	-	-	-	-
Household sizes increase (computed)	-	-	-	-
Driving licence changes (computed)	-	-	-	-
Working distance increase (computed)	-	-	-	-
Accessibility to the metro stations changes (computed)	-	-	-	-

Note: * P<0.1; ** P<0.05; *** P<0.01.

Twenty independent variables were considered in each model for sustainable transport users. After the forward selection based on the likelihood ratio was conducted, eight variables were entered into the final model. As illustrates in **Table 7**, older people are less likely to change their sustainable travel modes to use private cars. Older people are less able to learn how to drive a car and are less willing to change their lifestyles, which could be an explanation for this result. Like the previous model conclusion, renters, including those who have pro-metro attitudes and those whose workplaces are connected to metro services, are less likely to change their sustainable travel behaviours. Moreover, it is interesting to note that a higher

level of final income could cause a higher probability of switching from using sustainable travel to using private cars, rather than an increased level of income. Thus, a potential income threshold in individuals' minds may encourage car use other than the accelerated speed of one's income growth. Similarly, an increase in accessible metro stations may not necessarily stop people from using cars, although a high standard of accessibility to metro stations would prevent more sustainable travellers from becoming unsustainable. Whether a household includes children does not significantly determine one's travel behaviours, based on the results drawn previously; the more children are present in a household, the more likely it is that sustainable travellers will switch to using cars. One possible reason for this is that the presence of new-born children in a household within a certain period negatively affects the parents' abilities to manage their time. Thus, they may need private vehicles to shorten their time during commutes and to access multiple destinations for their children during one trip. The impact of increasing car numbers aligns with normal expectation. Purchases of cars at a certain point in life is a common cultural practice in China, although it does not necessarily relate to travel demands. However, such a purchase would increase an individual's interests in and desire to use to cars, which could result in more people giving up their sustainable travel behaviours.

Table 8 Logistic regression analysis results for private car users' travel behaviour changes

Independent Variables	**B**	**df**	**Sig.**	**Exp(B)**
Constant	-1.633***	1	0.000	0.195
Variables entered				
Workplace metro accessibility	1.625***	1	0.000	5.079
Attitudes	-1.793***	1	0.001	0.166
Accessibility to the metro stations changes (computed)	1.155***	1	0.001	3.174

Note: * P<0.1; ** P<0.05; *** P<0.01.

As for the binary logistic regression model used for private car users' travel behaviour changes, the same twenty independent variables were considered, but only three variables were chosen during the forward selection (likelihood ratio) (see **Table 8**). Thus, it is easy to conclude

that few elements can encourage car users to give up their existing travel behaviours and take more sustainable transport, which is consistent with the situation found in the descriptive statistic results. In contrast to the model for sustainable transport users, metro-accessible workplaces and pro-metro attitudes can reduce car users' resolve to continue using unsustainable transport. Another valuable finding is that improved accessibility to metro stations can have a significant effect on attracting car users to sustainable transport. Accessibility does not necessarily need to reach a high level of convenience, but the process of improvement would have a greater effect on car drivers' behavioural changes. Increasing car users' interest in metro accessibility, as well as increasing their interest in metro service itself, would be the consequence of metro accessibility improvement.

6. Conclusions

This dissertation discussed the wider impacts of TODs on residents' travel behaviours and the consistency of their travel behaviours over time to contribute to a more sustainable society with a higher sustainable travel sharing rate and to offer valuable insight to the fast-growing metro infrastructures China has invested in. To achieve this, the researcher used a sample of 1,298 respondents who resided in two sites with different TOD types in Hangzhou, China and investigated their travel behaviours, socio-demographic information, built environments and attitudes, as well as the same variables from five years earlier. Three binary logistic regression models were then applied as the key methodology to process the collected data, which were summarised in three tables which identify the key variables which determine the possibility of having sustainable travel behaviours, the possibility of shifting from sustainable transport to cars and the possibility of shifting from cars to sustainable transport over time.

The results demonstrate that remote new TOD projects are more attractive to younger generations due to their high architectural quality and green infrastructure and that the high-density TODs, which are based on existing residences, form more aged and changeless communities. This dissertation also claims that the compact design of vertically mixed land use in new TOD projects could create barriers for cyclists, so the author suggests that a more comprehensive cycle pathway network be implemented in future new TOD designs. Private car drivers who live in TODs have also been proven to be less likely to change their travel behaviours to include any sustainable travel modes, with a retention ratio of approximately 70%, which is consistent with the behaviours of ordinary private drivers who live in non-TOD areas (Chen et al., 2017). The increased number of metro users in the cities largely come from the availability of other sustainable transport methods and car drivers are most likely not caring about any public transport developments once they start to use a car.

The outcomes also show that age, education, monthly income, household size, residential tenure, working distance, workplace metro accessibility, convenient access to the metro stations and travel attitudes of each resident are the significant variables impacting TOD residents' travel choices. The association between age and travel behaviour differed from the association which exists in Western countries (Van den Berg et al., 2011) as a result of a

relatively new motor culture in China. Additionally, an individual's educational level has a positive relationship with car use for the residents in TOD areas, which opposes any existing travel behaviour studies. One possible hypothesis for this difference is that metro services could hold a more significant attraction for less-educated individuals who live within a metro service buffering area. This demonstrates that green advertising in schools as well as in higher learning institutions is important for facilitating an eco-friendly society (Yoon & Kim, 2016). The association between household size and travel behaviour also contradicts the findings of Western researchers (Susilo et al., 2012), which could be explained by the culture difference between Chinese families, who are used to offering family members rides to work or school and stay in one car to create a sense of family and privacy, and Western families. Children were not found to be a significant variable among TOD residents as the Hangzhou metro stations provide an evenly comfortable, safe and fast service in comparison to private cars.

Moreover, this study acknowledged the age, monthly incomes, residential tenure, workplace metro accessibility, convenient access to metro stations, travel attitudes, an increase in car ownership and children number as variables which affect the consistency of sustainable travel behaviours. The findings reveal that increased accessibility to metro stations does not necessarily stop people from using cars, although a high standard of accessibility in metro stations could prevent more sustainable travellers from becoming unsustainable. The presence of new-born children in a household who were born within a relatively close period could push parents to shorten their commuting time and facilitate the need for a car in order to access multiple destinations during one trip. Based on the study of consistency related to car travel behaviours, only a few elements can encourage car users to give up private vehicles and use more sustainable transports. These elements include workplace metro accessibility, travel attitudes and accessibility changes in the metro stations. The outcomes indicate that, instead of attaining a high level of convenient access to the metro stations, the process of improvement itself could have more effect on changing car drivers' behaviour.

Although a vast number of travel behaviour studies have been conducted in Western countries and China and many have discussed and tested possible variables (including socio-demographics, built environment and attitudes), few similar studies have specifically examined TOD residents' characteristics to determine a higher resource efficiency for metro

developments, and the number of studies that have examined the consistency of individuals' travel behaviours over time is limited. The results of this dissertation broaden the current studies on travel behaviours from the perspective of TOD residents and travel behaviour consistency.

This research contributes to the literature by observing the unique variables associated with TOD residents' travel behaviours specifically, and taking into consideration of the consistency of individuals' travel behaviours over time. Based on the research outcomes, several policies could be implemented to encourage sustainable travel behaviours and promote behavioural consistency. The first policy should include compulsive green advertising in educational settings which appeals to all age ranges; it should also be present in universities. The second policy should focus on providing more rental housing around metro connections as renters are more likely to use metro services. The third policy should implement comprehensive built environment designs which include multiple green areas, areas that are accessible for pedestrians and improved cycling networks within the new TOD properties. The fourth policy should encourage a longer age gap between children to reduce the suddenly increased public service demands which have already appeared and to ease individuals' daily commuting pressure and make them continue using sustainable transport. The fifth policy should implement regular upgrading to maintain metro stations' accessibility and should place more advertising in the communities to encourage private car users to change their travel modes.

Although this research helps to clarify the association between socio-demographic information, built environments, attitudes related to travel behaviour choices and consistency, it is still bounded by a few limitations. First, although it has been proven that no specific group was left out during the data collection and the regression models ran well, the built environment condition data were collected through questionnaires which depended on respondents' answers instead of actual fields work and evaluation of the sites due to the coronavirus (COVID- 19) pandemic. From this point of view, future researchers who study this subject should strongly suggest that the research include more TOD sites in the analysis instead of two typical examples; future studies should also incorporate more variables like housing size to improve the accuracy of the regression models. Additionally, a more advanced

mathematic methodology could be used to include the number of cars and drivers' licensing information without involving significant collinearity or multicollinearity in the model.

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Appendix 1: Survey questions

Travel behaviours of TOD residents

The purpose of this questionnaire is to investigate the impact of the development of Hangzhou Metro on the long-term travel mode of residents around metro stations and to provide suggestions for the future planning and policy formulation of Hangzhou Metro. The questionnaire is collected anonymously, your personal information will not be recorded, and the data will not be associated with your WeChat account and mobile phone number.

In order to analyze the long-term impact of the metro stations, the questionnaire will ask information about current and five years ago (2015). Please fill in the actual situation. Before starting the questionnaire, please make sure that you are over 18 years old and have provided true information. It is estimated that it will take 3 minutes to complete the questionnaire.

Workday travel behaviours

1.What's your present workday major travel mode? *

- ◯ By private car (please fill Q3)
- ◯ By metro (includes bus/cycle transfer) (please fill Q4)
- ◯ By Bus (includes cycle transfer)
- ◯ By cycle
- ◯ By walk only
- ◯ By Taxi

2.What's your workday major travel mode in 2015? *

- ◯ By private car (please fill Q3)
- ◯ By metro (includes bus/cycle transfer) (please fill Q4)
- ◯ By Bus (includes cycle transfer)
- ◯ By cycle
- ◯ By walk only
- ◯ By Taxi

3.What're your main reasons for using the metro at present?[多选题]

choose up to 3

- [ ] To protect the environment
- [ ] Metro is more comfortable
- [ ] Safer
- [ ] Faster
- [ ] More reliable (on time)
- [ ] Metro provides a social place
- [ ] No parking space at the workplace
- [ ] Using cost of private cars is high
- [ ] Fail to obtain a driver's license
- [ ] Unable to purchase a car
- [ ] others____

4.What're your main reasons for using the car at present?[多选题]

choose up to 3

- [ ] Family need me to use the car (eg. bring kids to school)
- [ ] My work needs me to use car
- [ ] Would be looked down upon if not using car
- [ ] More comfortable
- [ ] Safer
- [ ] Faster
- [ ] More private
- [ ] More flexible
- [ ] others____

Socio-demographics

5.Gender *

- ◯ Male
- ◯ Female

6.Age *

- ◯ 18~25
- ◯ 25～30
- ◯ 30～35
- ◯ 35~45
- ◯ 45～55
- ◯ 55～65
- ◯ 65+

7.Education *

- ◯ Mid school and below
- ◯ High school
- ◯ College & Undergraduate
- ◯ Postgraduate & above

8.marriage statuse *

- ◯ Single
- ◯ Married

9.Your monthly incomes *

	¥ 2,000–3,000	¥ 3,000–5,000	¥ 5,000–10,000	¥ 10,000–15,000	¥ 15,000–20,000	¥ 20,000+
Present Monthly incomes	◯	◯	◯	◯	◯	◯
2015 Monthly incomes	◯	◯	◯	◯	◯	◯

10.Number of household members (includes you) *

	1	2	3	4	5	6+
Present household size	○	○	○	○	○	○
2015 household size	○	○	○	○	○	○

11.Number of children in your household (under 18) *

	0	1	2	3+
Present children number	○	○	○	○
2015 children number	○	○	○	○

12.Residential tenure *

○ Owner

○ Renter

13.Number of cars in your household *

	0	1	2	3+
Present car number	○	○	○	○
2015 car number	○	○	○	○

14.Do you have a driving licence? *

	Yes	No
Present driving licence	○	○
2015 driving licence	○	○

Built environment

15.Working distance *

	< 1km	1～5km	5～10km	10～20km	20km+
Present working distance	○	○	○	○	○
2015 working distance	○	○	○	○	○

16.Workplace metro accessibility *

	Yes	No	Access by walk/cycle	I don't know
Present workplace metro accessibility	○	○	○	○
2015 metro accessibility	○	○	○	○

17.Do you have a pleasant walking environment in your neighbourhood? *

	Yes	No	I don't know
Present pleasant walking environment	○	○	○
2015 pleasant walking environment	○	○	○

18.Do you have a pleasant cycling environment in your neighbourhood? *

	Yes	No	I don't Know
Present pleasant cycling environment	○	○	○
2015 pleasant cycling environment	○	○	○

19.Do you have convenient access from your home to the metro stations? *

	Yes	No	I don't know
Present convenient access to the metro stations	○	○	○
2015 convenient access to the metro stations	○	○	○

Travel attitude

20.Travel attitude *

○ I prefer to travel by metros

○ I prefer to travel by private cars

21.What services are lacking in your neighbourhood?[多选题] *

choose up to 3

☐ Employment

☐ Restaurants

☐ Shopping places

☐ Shopping places

☐ Grocery markets

☐ Greens & parks

☐ Children's education

☐ Community health centre

☐ Elder's recreation centres

☐ Sports centre

☐ *Services are adequate

☐ others____

22.What's your non-working days' major travel mode? (weekends, holidays, after works) *

- ◯ By private car
- ◯ By metro (includes bus/cycle transfer)
- ◯ By bus (includes cycle transfer)
- ◯ By cycle
- ◯ By walk
- ◯ By taxi

23.What're your main travel purposes during the non-working time?[多选题] *

choose up to 3

- ☐ Dining out
- ☐ Shopping
- ☐ Grocery shopping
- ☐ Entertainment
- ☐ Social activity
- ☐ Extra-curricular classes for kids
- ☐ others____

Appendix 2: Risk assessment form

RISK ASSESSMENT FORM
FIELD / LOCATION WORK

The Approved Code of Practice - Management of Fieldwork should be referred to when completing this form
http://www.ucl.ac.uk/estates/safetynet/guidance/fieldwork/acop.pdf

BSP- MSC TRANSPORT AND CITY PLANNING

HANGZHOU, CHINA

Tonggaochuan Shen

Meet two sites' neighbourhood committees first and send the online questionnaires links to their communities' social groups (Wechat groups in this case) in order to gather the desired data.

Consider, in turn, each hazard (white on black). If **NO** hazard exists select **NO** and move to next hazard section.

If a hazard does exist select **YES** and assess the risks that could arise from that hazard in the risk assessment box.

Where risks are identified that are not adequately controlled they must be brought to the attention of your Departmental Management who should put temporary control measures in place or stop the work. Detail such risks in the final section.

ENVIRONMENT	**The environment always represents a safety hazard. Use space below to identify and assess any risks associated with this hazard**
e.g. location, climate, terrain, neighbourhood, in outside organizations, pollution, animals.	**No risk**

CONTROL MEASURES	**Indicate which procedures are in place to control the identified risk**
	work abroad incorporates Foreign Office advice
	participants have been trained and given all necessary information
	only accredited centres are used for rural field work
	participants will wear appropriate clothing and footwear for the specified environment
	trained leaders accompany the trip
	refuge is available
	work in outside organisations is subject to their having satisfactory H&S procedures in place
	OTHER CONTROL MEASURES: please specify any other control measures you have implemented:

EMERGENCIES	**Where emergencies may arise use space below to identify and assess any risks**

e.g. fire, accidents	**No risk**

CONTROL MEASURES	**Indicate which procedures are in place to control the identified risk**
	participants have registered with LOCATE at http://www.fco.gov.uk/en/travel-and-living-abroad/
	fire fighting equipment is carried on the trip and participants know how to use it
	contact numbers for emergency services are known to all participants
	participants have means of contacting emergency services
	participants have been trained and given all necessary information
	a plan for rescue has been formulated, all parties understand the procedure
	the plan for rescue /emergency has a reciprocal element
	OTHER CONTROL MEASURES: please specify any other control measures you have implemented:

EQUIPMENT	**Is equipment used?**	**NO**	**If 'No' move to next hazard** **If 'Yes' use space below to identify and assess any risks**
e.g. clothing, outboard motors.	Examples of risk: inappropriate, failure, insufficient training to use or repair, injury. Is the risk high / medium / low ?		

CONTROL MEASURES	**Indicate which procedures are in place to control the identified risk**
	the departmental written Arrangement for equipment is followed
	participants have been provided with any necessary equipment appropriate for the work
	all equipment has been inspected, before issue, by a competent person
	all users have been advised of correct use
	special equipment is only issued to persons trained in its use by a competent person
	OTHER CONTROL MEASURES: please specify any other control measures you have implemented:

LONE WORKING	**Is lone working a possibility?**	**NO**	**If 'No' move to next hazard** **If 'Yes' use space below to identify and assess any risks**
e.g. alone or in isolation	Examples of risk: difficult to summon help. Is the risk high / medium / low?		

lone interviews.

CONTROL MEASURES	Indicate which procedures are in place to control the identified risk
	the departmental written Arrangement for lone/out of hours working for field work is followed
	lone or isolated working is not allowed
	location, route and expected time of return of lone workers is logged daily before work commences
	all workers have the means of raising an alarm in the event of an emergency, e.g. phone, flare, whistle
	all workers are fully familiar with emergency procedures
	OTHER CONTROL MEASURES: please specify any other control measures you have implemented:

ILL HEALTH	**The possibility of ill health always represents a safety hazard. Use space below to identify and assess any risks associated with this Hazard.**
e.g. accident, illness, personal attack, special personal considerations or vulnerabilities.	**No risk**

CONTROL MEASURES	**Indicate which procedures are in place to control the identified risk**
	an appropriate number of trained first-aiders and first aid kits are present on the field trip
	all participants have had the necessary inoculations/ carry appropriate prophylactics
	participants have been advised of the physical demands of the trip and are deemed to be physically suited
	participants have been adequate advice on harmful plants, animals and substances they may encounter
	participants who require medication have advised the leader of this and carry sufficient medication for their needs
	OTHER CONTROL MEASURES: please specify any other control measures you have implemented:

TRANSPORT	**Will transport be required**	**NO**	√	**Move to next hazard**
		YES		**Use space below to identify and assess any risks**
e.g. hired vehicles	Examples of risk: accidents arising from lack of maintenance, suitability or training Is the risk high / medium / low?			

CONTROL MEASURES	**Indicate which procedures are in place to control the identified risk**
	only public transport will be used
	the vehicle will be hired from a reputable supplier
	transport must be properly maintained in compliance with relevant national regulations
	drivers comply with UCL Policy on Drivers http://www.ucl.ac.uk/hr/docs/college_drivers.php
	drivers have been trained and hold the appropriate licence
	there will be more than one driver to prevent driver/operator fatigue, and there will be adequate rest periods
	sufficient spare parts carried to meet foreseeable emergencies
	OTHER CONTROL MEASURES: please specify any other control measures you have implemented:

DEALING WITH THE PUBLIC	**Will people be dealing with public**	**NO**	**If 'No' move to next hazard** **If 'Yes' use space below to identify and assess any risks**

e.g. interviews, observing	Examples of risk: personal attack, causing offence, being misinterpreted. Is the risk high / medium / low?

CONTROL MEASURES	**Indicate which procedures are in place to control the identified risk**
	all participants are trained in interviewing techniques
	interviews are contracted out to a third party
	advice and support from local groups has been sought
	participants do not wear clothes that might cause offence or attract unwanted attention
	interviews are conducted at neutral locations or where neither party could be at risk
	OTHER CONTROL MEASURES: please specify any other control measures you have implemented:

WORKING ON OR NEAR WATER	**Will people work on or near water?**	**NO**	**If 'No' move to next hazard** **If 'Yes' use space below to identify and assess any risks**
e.g. rivers, marshland, sea.	Examples of risk: drowning, malaria, hepatitis A, parasites. Is the risk high / medium / low?		

CONTROL MEASURES	**Indicate which procedures are in place to control the identified risk**
	lone working on or near water will not be allowed
	coastguard information is understood; all work takes place outside those times when tides could prove a threat
	all participants are competent swimmers
	participants always wear adequate protective equipment, e.g. buoyancy aids, wellingtons
	boat is operated by a competent person
	all boats are equipped with an alternative means of propulsion e.g. oars
	participants have received any appropriate inoculations
	OTHER CONTROL MEASURES: please specify any other control measures you have implemented:

MANUAL HANDLING (MH)	Do MH activities take place?	NO	If 'No' move to next hazard If 'Yes' use space below to identify and assess any risks
e.g. lifting, carrying, moving large or heavy equipment, physical unsuitability for the task.	Examples of risk: strain, cuts, broken bones. Is the risk high / medium / low?		

CONTROL MEASURES	Indicate which procedures are in place to control the identified risk
	the departmental written Arrangement for MH is followed
	the supervisor has attended a MH risk assessment course
	all tasks are within reasonable limits, persons physically unsuited to the MH task are prohibited from such activities
	all persons performing MH tasks are adequately trained
	equipment components will be assembled on site
	any MH task outside the competence of staff will be done by contractors
	OTHER CONTROL MEASURES: please specify any other control measures you have implemented:

SUBSTANCES	**Will participants work with substances**	**NO**	**If 'No' move to next hazard** **If 'Yes' use space below to identify and assess any risks**
e.g. plants, chemical, biohazard, waste	Examples of risk: ill health - poisoning, infection, illness, burns, cuts. Is the risk high / medium / low?		
CONTROL MEASURES	**Indicate which procedures are in place to control the identified risk**		

	the departmental written Arrangements for dealing with hazardous substances and waste are followed
	all participants are given information, training and protective equipment for hazardous substances they may encounter
	participants who have allergies have advised the leader of this and carry sufficient medication for their needs
	waste is disposed of in a responsible manner
	suitable containers are provided for hazardous waste
	OTHER CONTROL MEASURES: please specify any other control measures you have implemented:

OTHER HAZARDS	**Have you identified any other hazards?**	**NO**	**If 'No' move to next section** **If 'Yes' use space below to identify and assess any risks**
i.e. any other hazards must be noted and assessed here.	Hazard: Risk: is the risk		
CONTROL MEASURES	**Give details of control measures in place to control the identified risks**		

Have you identified any risks that are not adequately controlled?			
	NO	√	**Move to Declaration**
	YES		**Use space below to identify the risk and what action was taken**

Is this project subject to the UCL requirements on the ethics of Non-NHS Human Research?	**NO**
If yes, please state your Project ID Number	

For more information, please refer to: http://ethics.grad.ucl.ac.uk/

DECLARATION The work will be reassessed whenever there is a significant change and at least annually. Those participating in the work have read the assessment.

Select the appropriate statement:

√	I the undersigned have assessed the activity and associated risks and declare that there is no significant residual risk
	I the undersigned have assessed the activity and associated risks and declare that the risk will be controlled by the method(s) listed above

NAME OF SUPERVISOR Mengqiu Cao

FIELDWORK 5 May 2010