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Candidate name:	Dingrui Chen
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Supervisor name:	Mengqiu Cao

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Second marker name:	
Third marker name (if applicable):	

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Examine the Effects of Transit-Oriented Development on People's Travel Behaviour in Changsha, China

Dingrui Chen

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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.

Dingrui Chen
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Abstract

Transit-oriented development (TOD) has been widely studied, and has been introduced as one of the methods to reduce the use of cars in the developed world and in some well-developed regions in China. However, despite having one of the fastest metro (subway) developments among China's 'non-first-tier cities', not to mention vast TOD and other forms of urban development, the city of Changsha has not received much attention in this field. To fill the gap, this research aims to study the relationship between TOD and people's travel behaviour in Changsha. An online survey was administered to 239 persons, and a binary logistic regression model was used to identify the factors that lead people to take the metro. There are three key findings in this dissertation: 1) High accessibility to metro stations is the most significant factor that attracts people to use the metro, while reducing car ownership and restricting urban car parking also play certain roles; however, sociodemographic factors such as gender, age, and income are not significant in this aspect. 2) Increasing land-use diversity and optimising a walking- and cycling-friendly design can help boost neighbourhood travel and reduce car usage, though increasing density is not likely to help much in this perspective. Finally, 3) few people have a TOD-style daily travel mode—that is, going from home to work and shopping, either using convenient public transit or walking and cycling—and most of them must prioritise housing prices and layout while choosing their residences, though they are still interested in living in a neighbourhood with TOD attributes. To better achieve TOD in Changsha, urban planners and policymakers should further improve the experience of non-car urban travel, optimise neighbourhood design and planning, and increase investments in affordable housing to achieve greater freedom of housing choice.

Keywords

Transit-oriented development; Travel behaviour; Residential self-selection; Changsha

1. Introduction

1.1 Background

In a post-Second World War world, suburbanisation has become a serious issue for urban planners to avoid or solve. Newman and Kenworthy (1999a) called this period the 'automobile-dependent city' because of the surge in the use of automobiles; urban planning also aims to satisfy automobile travel. Driving can raise a series of issues—for instance, seriously disrupting community life and threatening resident's safety (Monbiot, 2019), increasing people's driving costs and putting pressure on the city's fuel supply due to the rise in fuel demands (Aftabuzzaman & Mazloumi, 2011), and ultimately producing the highest economic and environmental costs (Newman and Kenworthy, 1999b). To successfully avoid the dominance of automobiles on city planning, the primary travel mode ought to be changed from cars to walking, bicycling, and public transport, which should be realised by putting the development focus back on the compact urban form with high density and mixed land-use while fully integrating mass urban transit into people's demands for urban travel. Transit-oriented development (TOD) is the conceptualisation of this idea, and it commonly requires the development of a compact and mixed-use urban form near the transit nodes, from which as many residential, commercial, and social activity amenities as possible should be available within walking distance (Calthorpe, 1993; Cervero, 2004).

In 1993, American architect Peter Calthorpe was the first person to introduce the concept of TOD, which caused widespread attention in Europe and Asia. Calthorpe (1993: 16) argues that the old style of the American Dream, the 'suburbia' lifestyle, should be abandoned, and people ought to embrace an alternative type of neighbourhood in which amenities for shopping, civic services, employment, and transit should be placed where people can easily reach them on foot from their residences and places of entertainment and education, so that walking and using transit can be as accessible as using the car in meeting the community's daily needs. He calls such neighbourhoods 'TOD' or 'pedestrian pockets,' and believes it should be the appropriate direction of future development for the fragmented American metropolis (Calthorpe, 1993: 16–17). In fact, urban expansion similar to TOD also happened prior to Calthorpe's argument. What Newman & Kenworthy (1999a) described as 'the transit city' in the 1880s shares some commonalities with TOD, such as creating walking-scale small towns—the 'subcentres'—and developing around the transit nodes, but those subcentres are mostly low-density with some 50 to 100 individuals per hectare. Unfortunately, the popularity of private cars changed the focus of urban planning and did not continue to develop in this direction. With the extension of urban highways and the increased numbers that the road network can reach at the destination, not only can the private car be viewed as being indispensable in urban interactions, it can also be considered a symbol of personal freedom as well (Webber, 1963). The problem is, maximised private car ownership results in serious damage to the city because of high private car accessibility (Mumford, 1961: 23), which eventually led to the birth of various city planning transformation and transport sustainability theories, including TOD.

TOD has been viewed as a significant solution to current automobile-related urban transport problems. Through developing residences near transit stations, TOD can encourage people to take the transit. Moreover, compact and diverse neighbourhood development, and the provision of necessary services within walking distance, can also reduce the need for long-distance travel by car (De Vos *et al.*, 2014). In the West, the practice of TOD started relatively earlier—for instance, with the well-known 'Finger Plan' (*Egnsplan*) of Copenhagen, Denmark, which successfully helped the transit system draw commuters away from private cars (Knowles, 2012). On the other side of the world, the unprecedented speed of economic development and urbanisation since 1978 also made China experience the urban automobile issue. Between 1997 and 2020, China saw a 12- to 16-fold increase in the number of automobiles, with a 50% annual growth of private cars (Kenworthy & Townsend, 2002). As a response to the growing automobile-dependent urban expansion and suburbanisation, major cities in China are trying to expand their rail transport services to the urban periphery, and TOD has also been widely implemented (Pan *et al.*, 2011). In 2005 and 2006, the Chinese authority issued two policies, 'Notice on Giving Priority to the Development of Urban Public Transportation' and 'Opinions on Several Economic Policies on Prioritising Urban Public Transport Development' (State Council, 2005; MHURD *et al.*, 2006), both of which clearly state the support for urban public transport development.

1.2 Research Aims and Objectives

This study aims to investigate the relationship between TOD and people's travel behaviour in Changsha. To this end, three research objectives were established:

1. identify the relationships between sociodemographic and transport-related factors and people's tendency to use the metro for urban travel;

2. identify the changes needed in a neighbourhood to attract people to boost their neighbourhood travel; and

3. study how many people now have 'TOD lifestyles' in Changsha and understand their attitudes on residential self-selection.

1.3 Structure of this Dissertation

The rest of the dissertation is structured into the following 5 chapters. Chapter 2 reviews the historical literature and explores the research gap in this field. Chapter 3 introduces the research methodology, including the case study, as well as data collection and analysis methods. Chapter 4 provides the results of the data analysis and discusses these results. Chapter 5 offers the conclusion.

2. Literature Review

2.1 The Concept of TOD

The functionality and viability of TOD relies on the change of people's travel behaviour from using private cars to walking, cycling, and using transit. In doing so, the corresponding design in the built environment must be made according to the requests of TOD officials. Locations near a new or existing public transport node that can provide high-quality and high-efficiency transit services should be chosen for the development of a dense, mixed-use neighbourhood including housing, businesses, community activities, and civic services (Cervero, 1998; Curtis *et al.*, 2009; Loo *et al.*, 2010). As a result, the need for people living in a TOD neighbourhood to have long-distance daily trips should be reduced thanks to the compact and mixed land use. At the same time, people can visit other parts of the city by simply using convenient and highly effective public transport services instead of cars. Moreover, a more convenient walking system that provides high accessibility to transit stations can further promote walking and using transit, especially in a relatively low-density suburb (Crowley *et al.*, 2009). In addition to promoting such designs, people's attitude may also have an impact on travel behaviour. People may choose to live in a place where they can use their favoured travel methods as much as they want. A study from Cao *et al.* (2007) indicates that people's favourable attitude toward the neighbourhood and/or travel can directly affect their residential self-selection, which in turn influences travel behaviour. After they have moved to the new neighbourhood for a certain length of time, the weight of the built environment factors on people's travel behaviour decisions may decrease, while sociopsychological factors may gain more weight as time goes by (Guo & Chen, 2007).

2.2 The Built Environment and People's Travel Behaviour

According to Ewing & Cervero (2001), the built environment can be a significant explanation of people's travel mode choices, a major determinant of their travel distance, and a secondary decisive factor in travel frequency. Handy *et al.* (2005) find that, instead of being described as 'correlation', there is actually a causal association between the built environment and people's travel behaviour. The Three Ds (density, diversity, and design) summarised by Cervero & Kockelman (1997) are thought to be the fundamental built environment dimensions in TOD design (Singh *et al.*, 2014). High-density and diverse land-use patterns can reduce the average travel distance, which, along with design centred around non-motorised travel, can be catalysts of active travel (Curtis & Olaru, 2010).

The impact of density on people's travel behaviour have long been acknowledged. Levinson & Wynn (1963: 61–62) indicates that different classes of density can have different transport services, which represent different travel behaviours. Studies from Dunphy & Fisher (1996) and Kockelman (1995) about family travel behaviour find that people's choice of private car use is more often decided by regional population density, and they are largely negatively correlated. The level of traffic congestion is strongly correlated with population density, and more compact urban land-use should help reduce congestion (Hahn *et al.*, 2002; Sarzynski *et al.*, 2006). In the practice of TOD, because of

high-density and compact development in the area surrounding transit stations, it is expected that people may be less likely to use private cars. This is different from transit-adjacent development (TAD), which also requires development to be close to the transit nodes but are generally low-density and private car-friendly (Dittmar & Poticha, 2004; Renne, 2009). To compete with cars, the commuting time when using transit should be close to or lower than commuting time when using cars, which limits the number of stops that can be set. For a low-density development, each station can serve fewer people than a high-density development in the same coverage area, which results in low transit ride volumes and threatens the system's viability (Curtis, 2008).

Diversity is also a significant dimension, and represents a mixed land-use pattern. It indicates the ability to provide a wide range of services, conveniences, and activities for different ethnicities, races, ages, careers, genders, and families (Ogra & Ndebele, 2014: 540). In a TOD neighbourhood, the diversity should be reflected in the variety of housing, as well as in various retail, leisure, and employment opportunities (Kooshian & Winkelman, 2018). Increasing diversity can promote a decrease in private car use. For instance, establishing a wide range of retail stores in the community can fulfil the needs that might otherwise require long-distance travel if there were fewer stores; thus, more walking and cycling trips can replace car driving (Cervero & Radisch, 1995; Handy, 1992). The increase of land-use diversity means enlarging the population that neighbourhood facilities can serve, so more people will be drawn to neighbourhood travel.

Neighbourhood design should encourage walking, cycling, and using transit while shaping a sense of place. In detail, mixed land-use should be realised with careful arrangement and balance; access to transit stations should be designed to be high in safety and convenience; and community facilities should contribute to the development of a good built environment (Gutiérrez *et al.*, 2011; Santos *et al.*, 2010). Even though many features of TOD are discussed and studied at a macro level—the policy-and-planning scale—it is only at the scale of urban design that actual limitations on space, time, and budget can be considered and coordinated in the real practice (Jacobson & Forsyth, 2008: 54). The influences of design on people's travel desires should be balanced with the effects of density and diversity. Appropriate design can achieve both easy accessibility to destinations on foot, and convenience for people walking, cycling, and taking transit because of the facilities provided (Cervero & Kockelman, 1997: 201). Nevertheless, it should be noticed that design is also the dimension in which the public is the most deeply involved. A lack of enough meaningful public participation should have a negative impact on the decision quality of the community design, and should hurt the diversity of the feedback sources (Bailey *et al.*, 2007).

2.3 Attitude, Residential Self-selection, and People's Travel Behaviour

In the field of psychology, an 'attitude' is defined as the psychological tendency appearing in the assessment process when people express a certain degree of preference or antipathy toward a specific entity (Eagly & Chaiken, 1993: 1). Attitude, decided by the possible consequences of a certain

behaviour and the assessment of such consequences, is one of the significant beliefs that can influence travel behaviour, but the influence should only be indirect, expressed through intentions (Bohte *et al.*, 2009). Between attitude and travel behaviour, residential self-selection should be the bridge to explain their relationship. It is even thought that it may be personal preference (in this case, attitude) that plays the key role in the process of the built environment influencing people's travel behaviour, and people should choose where to live according to their preferred travel mode (Wang *et al.*, 2011). Thus, in the context of TOD, it may not be that people minimise the use of private cars because they live in a TOD neighbourhood, but rather that they choose to live in a TOD neighbourhood because they want to rely on cars less.

Taking self-selection into consideration may raise the complexity in this perspective, because personal preference will account for a greater weight in deciding people's travel behaviour. Consequently, only people who prefer the changes of TOD will be attracted by a TOD neighbourhood, whilst people who do not prefer such changes may not, so it should be difficult to improve the traffic mode through planning efforts alone. Studies by Schwanen & Mokhtarian (1998; 2005a) reveal that, in the suburbs, the influences of the built environment can be higher than the effect of people's residential choices based on their favoured travel modes, at least for frequent trips with clear targets. In an urban area, travel behaviour is more balanced between residents' favourable attitude and limitations in the infrastructure. They also find that self-selection should only have a limited influence on the relationship between land use and travel behaviour, though it does exist, while it is easier for residents who prefer a suburban lifestyle to adapt to an urban lifestyle than the opposite situation (Schwanen & Mokhtarian, 2005b). As can be seen, residential self-selection may not have such a big impact compared to the built environment. Cao *et al.* (2006) discover similar phenomena in which the characteristics of the neighbourhood, especially the design of the shopping district, can strongly affect the frequency of residents' shopping, and fewer cars on the street can encourage people to walk. However, residential self-selection also has a significant effect on individual travel decision, which is more likely to explain the possibility of shopping on foot (Cao *et al.*, 2006; 2009). Therefore, self-selection is not ineffective but does have a relatively smaller effect in this process, and its interaction with the built environment also make its influence ambiguous.

Even though self-selection may not directly connect with people's travel behaviour, it may be the touchstone for travellers to try non-car travel modes. Findings from Lund (2006) indicate that though families who prefer taking transit choose to live in TOD neighbourhoods, they still do not account for the majority, while most people do not use public transport services but do enjoy other benefits such as a high-quality neighbourhood and low housing costs. TOD is not only about sustainable travel behaviour but also about creating a high-quality neighbourhood. If people are attracted by its high-quality neighbourhood design, they are likely to change their travel habits after they become used to living in such an environment. This is shown by Kamruzzaman *et al.* (2013), who finds that those people may also view transit services as a reserved travel choice, and the built environment can have a

certain effect on attitude adjustment. Compared to the built environment, people's attitude is not static but constantly adapts to the environment, which ultimately causes constant changes in their travel preference. Car lovers may choose to live in a car-friendly neighbourhood, but if TOD is implemented in their neighbourhood, it will be harder for them to use cars due to the constraints on car use from the new environment, even though they are not interested in public transport (De Vos *et al.*, 2012). Under such circumstances, many may choose to switch their travel mode, unless they have a deep love for cars bordering on religious fanaticism, forcing them to find new residences.

2.4 Some TOD Studies Based on the Chinese Context

TOD is not absent in the Chinese urban planning system, but it did develop differences during its adaptation to this country's unique context. On the one hand, China shares similar reasons and approaches as the West in developing TOD. Cervero & Day (2008) state that the experiences of travellers in Western countries are largely replicated by their Chinese peers in cities like Shanghai and Beijing, including increasing commuting distances and a rising reliance on cars, as cities gradually developed. Similarly, Chinese cities are also trying to develop mass rapid transit to solve related problems (Zhang, 2007). On the other hand, despite sharing the same principle, the TOD experience in the West may not be suitable to China. Some studies (Lin & Shin, 2008; Zhang, 2004) find that mixed land-use and density should not be significant in attracting people to change their travel behaviour in many Chinese cities (or, more broadly, eastern Asian cities) that already have a high density and diverse land-use patterns. Planners may need to emphasise elements other than density and diversity in those cities if they want TOD to be better implemented (De Vos *et al.*, 2014; Sung & Oh, 2011). In addition to different urban forms, different social and cultural contexts should also lead to different travel preferences and choices. Chinese with higher incomes tend to view the car as an indicator of social status and wealth due to greater mobility choices (Zacharias, 2005), hence they are willing to drive more as a way of showing off. Such an attitude about cars can be shifted because younger generations, who will shape the new generation of popular opinion, tend to pay more attention to sustainability and practicability, as is happening in developed countries.

2.5 Summary

The TOD neighbourhood should help to divert people's travel behaviour in two ways. First, in a TOD neighbourhood, most urban travel could be achieved by the transit system, which should pull customers from a reliance on cars. Current mass metro construction in Chinese cities reflects the will to encourage people using urban transit more often in their urban travels. The most common form of urban travel is commuting, but people also travel in the city for leisure pursuits and shopping, apart from commuting. Residents who are not biased against transit travel can be attracted to the transit system if a new metro stop is created near their residence, and those who prefer travelling by transit may also move to a TOD neighbourhood. Second, a considerable amount of active neighbourhood

travel should be boosted in a TOD neighbourhood. People should be able to enjoy most of the necessary services within walking distance, hence no need to travel to distant areas, which also means people may wish to go out more often. The Three Ds (high density, diverse land-use patterns, and a walking- and cycling-friendly design) help create a relatively fully functional living centre rather than a 'dormitory town'. For high-density Chinese cities, the main focus in implementing TOD should be on diversity and design, but the basic principle remains the same. Many people who are interested in such neighbourhood life should also be attracted to TOD neighbourhoods, regardless of their main travel preference, but their travel behaviour should also be influenced by the built environment after living there for a while.

2.6 Research Gap

Various studies have been made on the relationship among urban transit, TOD, and people's travel behaviour. On the one hand, a large number of studies on TOD have been made based mainly on the Western context, in particular for North American, Australian, and some European cities that developed heavily car-dependent suburbs (Cervero, 2004; Loo *et al.*, 2010; Messenger & Ewing, 1996; Renne, 2009; 2016). On the other hand, there are also a large number of studies on Chinese cities, but most of them focus on the few large first-tier cities, such as Beijing, Shanghai, Hong Kong, and Shenzhen, which have massive urban populations, well-developed and relatively balanced urban transit systems, and higher average incomes (Cervero & Day, 2008; Lin & Zong, 2006; Loo *et al.*, 2010; Zhang, 2007). As there at present are 113 Chinese urban areas with populations of over one million people (Routley, 2020), studies on other less-developed cities are generally lacking. As China's economy continues to develop, many other cities are slowly catching up with the pace of the first-tier cities, and there is even a new concept of 'new first-tier cities' to describe the most dazzling ones among them (Li, 2020). As with the first-tier cities, they are also interested in TOD, either seeing it as a solution to existing urban automobile issues, or viewing it as a precaution before the automobile crisis emerges. However, whether metro construction and TOD influence people's travel behaviour, and if so, how, are rarely researched in many of these cities.

3. Research Methodology

3.1 City Context

Changsha is the capital city of Hunan Province (see Figure 3.1) with an urban population of roughly 8.4 million in 2019 (SBCC, 2020). In concert with the nation as a whole in the last two decades, Changsha experienced a roughly 110-fold surge in its GDP from 1991 to 2018 (NBS, 2019). Meanwhile, the city's private car ownership also became the highest in the province, with around 2.6 million automobiles in late 2019 (Zhou & Xie, 2020). In the same period, there was no stagnation in the development of the public transport. One of Changsha's oldest and most typical public transport system is the bus system, and there are 3,775 vehicles in the system in 2012. Much of the transport

capacity is wasted because of duplicated bus routes, and it is hard to determine the buses' arrival time as a result of heavy congestion (Zhu, 2014). These factors deter people from using public transport, so Changsha introduced the metro (subway) system in the hope of improving its status.

Figure 3.1. Location of Changsha (Source: Wu, 2018)

In the field of urban transit, Changsha's metro is not well-known, but this has gradually changed since its metro network began growing. The metro is relatively new in Changsha, but it developed at a rapid pace. In 2009, the State Council and National Development and Reform Commission approved the 'Construction Planning of Urban Rapid Rail Transit in Changsha (2008–2015)'. In 2009, the first route of Changsha metro, Line 2, began construction and was opened in 2014. As of 2020, the city now has five lines in operation with two more under construction, and the full length of its metro system reaches a total of 161.2 kilometres (Chen & Wu, 2020; CMG, 2019). Changsha's metro development has become one of the fastest in China. Not only have some specialised TOD-design projects been proposed, such as Yanghu Eco-Town, but some improvements in the built environment surrounding metro stations have also been implemented, which has been called 'Rail+', aiming to create an 'urban transit + function centre' development mode (CAUPD & CPDSRI, 2020: 29). The city deserves more focus; yet it is difficult to find any research on it. This dissertation is expected to fulfil the gap.

3.2 Methodology of Data Collection

An online survey with a self-completed questionnaire was used to collect data in this study. The questionnaire is a widely used instrument in social research, and it provides the chance to obtain a person's subjective thoughts, beliefs, and initial cognitions (Clark & Maguire, 2019: 1). 'Self-completed questionnaire' is a broad term that was created to distinguish this new type of questionnaire from 'postal questionnaire', which is a traditional method requiring the use of a hard copy to collect answers physically via the post or some other method (Bryman, 2012: 232). However, the traditional postal questionnaire method usually has a low response rate, which raises doubts on its results' reliability, while the online questionnaire provides an alternative that makes it convenient to mark invalid answers while avoiding the mailing and labour costs (Loban *et al.*, 2017: 116). With the popularity of personal computers and the advancement of network technology, it is easy to distribute an online questionnaire to a relatively larger number of participants compared to traditional methods, and the data collected from it does not require a digitalisation process to analyse. Moreover, in the context of the global pandemic, an online questionnaire should also be one of the safest survey methods because it helps avoid direct face-to-face contact. All of these can ensure that this research is within the study's ethics requirements.

The data are collected through a Chinese online survey platform, WenJuanXing, which is equivalent to SurveyMonkey, Qualtrics, and similar platforms in the West. The questionnaire consists of 11 questions, most of which are closed in format. As Bryman (2012: 246–252) indicates, participants can only choose their answers among the options specified in the closed question rather than writing whatever they want; the advantage of this is that data from the closed questions are easier to analyse and compare, while open questions are more time-consuming in both data-gathering and processing steps. Also, some questions use the Likert scale, which should be helpful in assessing the intensity of people's attitudes (Bryman, 2012: 239). The questions asked information about participants' personal information, such as gender, age, and income, but it also asked about their travel conditions, their opinions on neighbourhood living, and their residential self-selection preference. The random sampling approach has been used in this survey, for the questionnaire was sent randomly to employees in different workplaces in Changsha, and they were encouraged to distribute it among their colleagues.

3.3 Methodology of Data Analysis

As noted previously, this dissertation will cover three main objectives. As the main targets are to get objective facts and phenomena from the research, the quantitative research method is used because it produces more objective results than the qualitative method (Bryman, 2012: 160). To respond to Objective 1, IBM SPSS, a data analysis software package, will be used to test the related statistics. If there are two categories in a dichotomous dependent variable, and there is an observed entity to fit or be classified into one of the two categories according to a certain number of independent variables,

the tool to predict the results of such behaviour is called a binary logistic regression; thus, it should be the appropriate data statistical analysis method for this objective (Wongsasuluka *et al.*, 2018: 109). A simple linear regression aims to predict the outcome of one thing based on various independent variables, while a logistic regression aims to predict the probability of such outcomes actually occurring (Field, 2009). Though a binary logistic regression is believed to be an extension of simple linear regression, its dependent variable can only be dichotomous in nature, and it must be associated with two or more independent variables to be effective, which can be either continuous or categorical (Statistics Solution, no date). For this objective, the dependent variable should be 'Do people use the metro as their primary travel method when travelling in the city?', and there should be six independent variables to be analysed, covering the aspects of socio-demography and travel conditions.

However, before performing binary logistic regression analysis, it is necessary to measure the multicollinearity among the independent variables in case it can have a large impact on the results, making it unreliable. Variance inflation factor (VIF) is used to measure the severity of such collinearity in the linear regression (CFI, no date). For the i^{th} independent variable in the regression, Equation 1 shows the basic formula of VIF:

$$VIF_i = \frac{1}{1-R_i^2} = \frac{1}{Tolerance} \quad (1)$$

in which R^2 represents the unadjusted coefficient of determination and tolerance is the reciprocal of VIF.

If the variables can be proved to be not correlated with each other, then further analysis can be proceeded. The dichotomous dependent variable and the six independent variables used in the regression model are shown in Table 3.1. Equation 2 demonstrates the process of calculating the probability of the dependent variable Y occurring:

$$P(Y) = \frac{1}{1+e^{-(b_0+b_1x_1+b_2x_2+b_3x_3+b_4x_4+b_5x_5+b_6x_6)}} \quad (2)$$

In this equation, Y represents the dichotomous dependent variable, hence P(Y) represents the probability of the occurrence of Y, and X_1 to X_6 represent the six independent variables shown in Table 3.1. Apart from them, b_0 is a constant, e represents the base of natural logarithms, and b_1 to b_6 denote the coefficients attached to each predictor variable from X_1 to X_6.

Table 3.1. Variables in the binary regression model

Variable Types	Variables	Categories
Dependent	Metro as the main urban travel mode	= 1 If yes = 0 If no
Independent	Gender	= 1 If female = 0 If male

Age	= 1 If the age less than or equals to 40 = 0 If the age is larger than 40
Annual income	= 1 If annual income less than ¥150000 = 0 If annual income equals to or higher than ¥150000
Car ownership	= 1 If owns no car = 0 If owns at least one car
Major destination parking	= 1 If inconvenient to park = 0 If convenient to park
Metro station accessibility	= 1 If high = 0 If low

From the calculation of binary logistic regression, it is expected to output the model summary table indicating the reliability of the model, with the classification results telling the accuracy of the model's prediction, the contribution degree of each variable, as well as its statistical significance, which indicate the significance of the independent variable's impact on the results of the dependent variables. Chapter 4 will demonstrate the calculation results and discuss their possible explanations.

In terms of Objectives 2 and 3, their data have been collected through the remaining questions of the survey. The results, and discussion on the data, will also be presented in the next chapter.

4. Findings and Discussion

4.1 Descriptive Statistics

Both the distribution of the questionnaire and the collection of data were conducted and completed in July. A total of 268 questionnaires were collected from WenJuanXing. After excluding those with incomplete questions, 239 samples were analysed. A summary of the results of the collected data is shown in Table 4.1. According to the results, 51.46% of the participants are males and 48.54% are females, with the ratio of male to female around 1:1. Most of the respondents are concentrated in the age groups 21–30 and 31–40, and most of them have annual incomes of less than ¥150,000, with the details shown in Figures 4.1 and 4.2. Nearly half of them tend to use the car as their main travel mode in the city, while the metro is, surprisingly, the second least used travel mode, with only around 15% people choosing it. About two-thirds of respondents own cars, but parking at most of their destinations is either difficult to find or not allowed. In terms of metro accessibility, only one-third of respondents consider it highly accessible, while the rest either do not have a metro station near their home or the metro system cannot be accessed easily. However, over 80% of respondents prefer to travel in or around their neighbourhood for their basic needs.

Table 4.1. Descriptive statistics

Variables		Number	Percentage (n=238)
Gender	Male	123	51.46%
	Female	116	48.54%
Age (years old)	18–20	3	1.26%
	21–30	83	34.73%
	31–40	97	40.59%
	41–50	45	18.83%
	50+	11	4.46%
Annual Income	¥49,999 or less	71	29.71%
	¥50,000–¥99,999	76	31.80%
	¥100,000–¥149,999	56	23.43%
	¥150,000–¥199,999	10	4.18%
	Over ¥200,000	26	10.88%
Main Travel Mode in the City	Taking Metro	36	15.06%
	Taking Car	110	46.03%
	Taking Bus	49	20.05%
	Walking or Cycling	39	16.32%
	Others	5	2.09%
Car Ownership	Yes	157	65.69%
	No	82	34.31%
Major Destination Car Parking	Yes, allowed and convenient	83	34.73%
	No, allowed but inconvenient	107	44.77%
	No, not allowed	49	20.05%
Metro Station Accessibility from Home	Yes, easy to access	84	35.15%
	No, hard to access	50	20.92%
	No, no metro station exists	105	43.93%
Travelling In or Around the Neighbourhood for Basic Living Needs	Yes	192	80.33%
	No, prefer to travel further	26	10.88%
	No, must travel further	21	8.79%

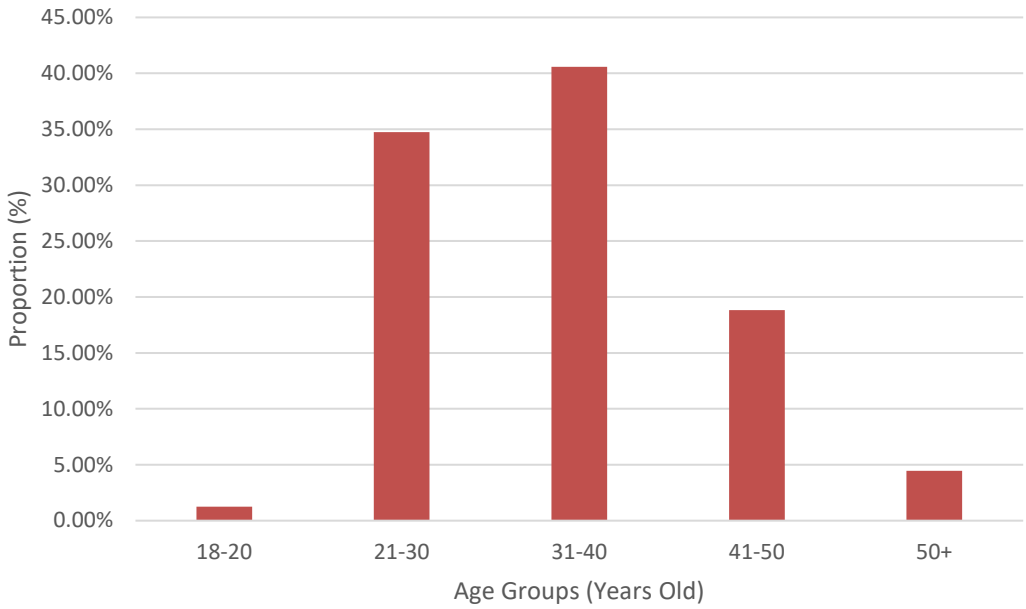

Figure 4.1. The proportion of respondents' age groups

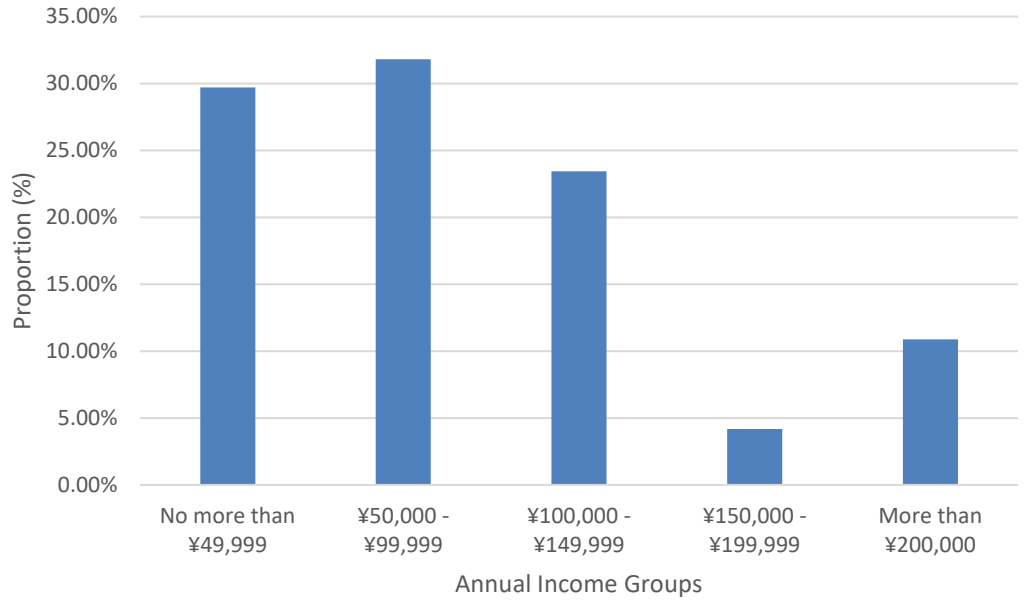

Figure 4.2. The proportion of respondents' annual income groups

4.2 Research on the Metro as the Main Urban Travel Mode

4.2.1 Results of the Binary Logistic Regression Model

Based on the discussion in Chapter 3, four tables have been created to indicate the binary logistic regression model's reliability, the accuracy of its results, and the significance of the independent variable's impact on the results of the dependent variables.

First of all, table 4.2 shows the calculation results. According to Glen (2015), a VIF close to 1 represents 'not correlated', thus tolerance should also close to 1 while being smaller than 1. As a

result, it can be assumed that multicollinearity is not significant among variables, and hence the results should be reliable. Therefore, further analysis can be proceeded.

Table 4.2. Variance inflation factor

Variables	Tolerance	VIF
Gender	.931	1.075
Age	.953	1.049
Annual Income	.945	1.058
Car Ownership	.951	1.052
Destination Parking	.994	1.006
Metro Station Accessibility	.939	1.065

Table 4.3 indicates the summary of the model and shows the square of the model's R-statistic. In liner regression, the fitting degree between model and data can be measured by R, the multiple correlation coefficient, as well as its R^2-value. For logistic regression, a more literal 'R-statistic' can be calculated that also measures the multiple correlation. For a better accuracy, instead of the R-value, the R^2-value should be used in linear regression, and there are also some similar terms in logistic regression in terms of interpretation. In SPSS, Cox and Snell's R^2 and Nagelkerke's R^2 have been used, and they vary between 0 and 1. For the perfected prediction of the model on the outcome variable, the value should be close to 1, otherwise it would close to 0. However, Cox and Snell's R^2 never reached its theoretical maximum of 1, hence Nagelkerke's R^2 becomes the amendment (Field, 2009: 268–269). In this model, Nagelkerke's R^2 is 0.502; hence, the explained variation in whether people are using the metro is 50.2%.

Table 4.3. Model summary table

-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
121.828	.287	.502

Table 4.4 shows the classification results of this model. In terms of people not using the metro as their primary travel mode within the city, it correctly classified 94.1% of cases, while for people using the metro as their primary travel mode, it correctly classified 58.3% of cases. Overall, the accuracy of this model is 88.7% which means that the model can correctly predict whether people choose to take the metro as their main urban travel mode in 88.7% of cases.

Table 4.4. Model classification table

Observed		Predicted		
		Take Metro?		Percentage
		No	Yes	Correct
Take Metro?	**No**	191	12	94.1
	Yes	15	21	58.3
	Overall Percentage			88.7

Table 4.5 provides some key results of the model's independent variables. As discussed in Section 3.3, this is used to determine the contribution of each independent variable to the outcomes of the dependent variable and their statistical significance. In this table, 'B' represents the regression coefficient b in Equation 2, 'Wals' represents the Wald statistic to test the statistical significance, which is also stated as 'Sig.', and 'Exp (B)' represents the odds ratio to measure variables' contribution (NCRM, 2011). The results reveal the following:

- Females are 1.444 times more likely to take the metro than males;
- People 40 years old or less are 1.356 times more likely to take the metro than those over 40;
- People with an annual income of less than ¥150,000 are nearly 2.5 times more likely to take the metro than those who earn ¥150,000 or more annually;
- People who do not own a car are nearly 3.75 times more likely to take the metro than people who own a car;
- People who cannot park the car at their primary destinations are nearly nine times more likely to take the metro than those who can park at their primary destinations;
- People who have a highly accessible metro station near their home are 41 times more likely to take the metro than those without an accessible metro station near their home.

As for statistical significance, also called the *P*-value, Bryman (2012: 348) and Rumsey (no date) state that the results can be considered significant if the *P*-value is less than 0.05, and it should be strongly significant if it is less than 0.001. In these results, gender, age, and annual income variables have *P*-values that are significantly larger than 0.05, so their results are insignificant, while destination parking and metro station accessibility should be highly significant. Though the *P*-value of car ownership is larger than 0, it is smaller than 0.05 and is significantly less than the first three, so it can be categorised together with the latter two.

Table 4.5. Modelling results

Independent Variables	B	S.E.	Wals	df	Sig.	Exp (B)
Female	.367	.483	.577	1	.447	1.444
People 40 years old or younger	.305	.611	.249	1	.618	1.356

Annual income less than ¥150,000	.919	.910	1.022	1	.312	2.508
Not owning a car	1.317	.524	6.318	1	.012*	3.732
Cannot park at major destinations	2.192	.625	12.299	1	.000***	8.951
Metro station accessibility	3.722	.632	34.731	1	.000***	41.335
Constant	-7.447	1.429	27.149	1	.000***	.001

Note: * *P<0.05*; ** *P<0.01*; *** *P<0.001*.

4.2.2 Discussion

According to the results of the binary logistic regression, the possibility of taking the metro as the main urban travel mode for people who do not own a car is around 3.75 times higher than those who own a car. This echoes the findings from Webber's (1963) study on American travel behaviour and Zacharias's (2005) study on Chinese travel behaviour. Despite their different historical, socioeconomic, and cultural contexts, people have similar reason for choosing a car. The car is a convenient transport tool providing higher urban mobility than other modes (partially because cities also preferred car-friendly design during mass urbanisation). In addition, a car allows people to enjoy the sense of freedom brought by its high mobility, and it lets people with high incomes show off their wealth and social status. This corresponds to the results on people's annual income, in which the lower-income population (below 150 thousand yuan) are two and a half times more likely to take the metro than the higher-income population. Higher income should mean more surplus funds, which can support people's desire to purchase, use, and maintain cars. Also, the metro is yet to be completed in Changsha, and there are still parts of the city not covered by the metro system. Considering that around two-thirds of the respondents in this survey own cars, these factors encourage people to continue to use the old travel mode—automobiles.

People who find it hard to park at their major destinations in the city because it is either not allowed or is allowed but parking is scarce, are nearly nine times more likely to use the metro than people who can easily park at their destinations. This undoubtedly includes those who do not own a car, but people can still use cars through car rental services, or they can borrow from their families, relatives, or friends so they still have easy access to cars. In this case, people must consider the parking conditions at their destinations. Restricting people's parking ability at their major destinations—for instance, their workplaces—can significantly reduce the use of cars, while other control methods, such as higher parking fees, can achieve the best effect only after the number of parking spaces has been reduced (Christiansen *et al.*, 2017). Since it is impossible to abandon the car upon arriving at their destinations, other transport modes must be considered if parking is inconvenient. From this perspective, Changsha metro, with its cheap prices and better facilities, is able to attract this group.

People with an accessible metro station near their homes are over 41 times more likely to take the metro than those without an accessible metro station near their homes. 'Accessible metro station' means that people should not only have a metro station within walking distance from home, but should be able to easily access these stations by walking or cycling. The reason for this huge gap comes from three perspectives. First, as mentioned before, low costs and good facilities could be a key attraction of metro. Second, due to residential self-selection, some people may choose to live near viable metro stations because they want to take the metro conveniently. Third, and most vitally, as Bivina *et al.* (2019) finds, the accessibility of metro stations, especially walking accessibility, can significantly affecting peoples' perception of using them, hence high accessibility can encourage people to use the metro. Only about one-third of the respondents have access to viable metro stations, revealing that service coverage for the Changsha metro is still insufficient. Unlike Western-style low-density development, as Curtis (2008) mentioned, the shortage of existing metro lines and stations due to the limited development time should be the reason for insufficient coverage in Changsha.

The regression model indicates that gender, age, and annual income do not have a significant impact on people's decision to take the metro. This shows that the metro in Changsha should be a socio-equal transport tool, and it should not exclude a certain group of people based on their sociodemographic conditions. Christiansen *et al.* (2017) finds females to be around one-third less likely to use cars to travel than males, which should contribute to the fact that females are roughly 1.5 times more likely to use the metro than males. People aged 40 or less are also more likely to use the metro than older patrons. In addition to income differences, younger people should more likely to overcome the inconvenience of taking public transport (such as crowding) due to their better physical and mental health condition. The issue of annual income has been discussed before, but besides the ability to purchase cars, higher incomes also mean they could simply purchase houses near their workplace, where housing prices are relatively high, which should also result in less of a likelihood to take metro.

4.3 Research on Active Neighbourhood Travel

4.3.1 Data Summary

Based on the existing literature, a TOD neighbourhood should fulfil the Three Ds concept: high density, diverse land-use patterns, and a walking- and cycling-friendly design. The respondents were given eight factors related to the Three Ds, which can be viewed in Table 4.6. Using a five-point Likert scale format, respondents answered how much the eight factors influence them in meeting their basic needs in or around their neighbourhoods. This is represented by Question 9 in the questionnaire. The respondents of this question were filtered from Question 8, which asked about people's current neighbourhood travel behaviour, and only those who did not travel frequently in or around their neighbourhood to meet basic needs were required to answer Question 9. According to Table 4.1, 47 of 239 respondents provided a negative answer in Question 8. The results can be seen in Figure 4.3.

Table 4.6. Factors asked in the survey

3Ds	Factors
Density	1. Increased population density
	2. Increased car density
	3. Increased development density
Diversity	4. More diverse land-use patterns
Design	5. Optimise the existing walking and cycling facilities
	6. Add more walking and cycling routes
	7. Add more car routes
	8. Add more parking spaces

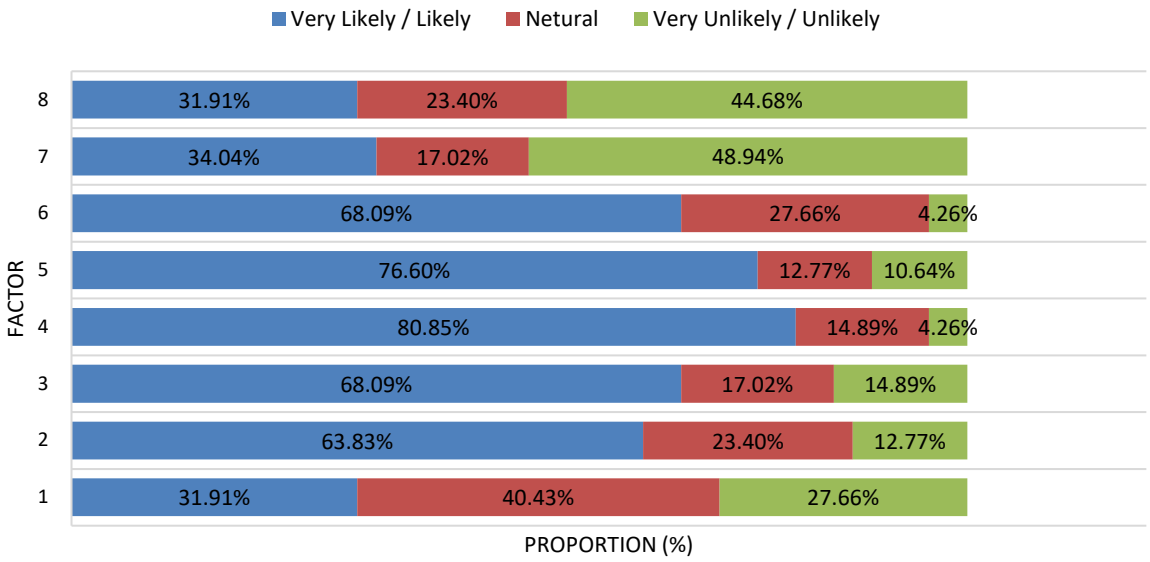

Figure 4.3. Factors influencing people's neighbourhood travel behaviour (serial numbers in "factor" axis are corresponding to those in table 4.6)

4.3.2 Discussion

The concept of density can be split into population density and development density. In terms of population density, Dunphy & Fisher (1996) and Kockelman (1995) proves its impact on travel behaviour, and people living in a higher population density neighbourhood are less likely to travel by car. This may result from the fact that a higher population density is more likely to cause traffic congestion (Hahn *et al.*, 2002), hence it could worsen the experience of using cars. In terms of basic living needs, such as essential shopping, barbering, entertaining, etc., if using the car is not easy and comfortable enough in their neighbourhood, people may be more likely to do these activities in or around their neighbourhood for convenience. This is proved by the results shown in Figure 4.3, where whether high population or car density can affect people's neighbourhood travel is assessed using

Factors 1 and 2. The results indicate that if car density is increased in the neighbourhood, which might be caused by higher population density (Factor 2), people are more likely to travel within or around the neighbourhood for basic living needs than if the population density were simply increased (Factor 1). It says that population density may not directly affect travel behaviour, but that it should have an effect on it through influencing local car density and other corresponding factors.

Development density (Factor 3) is associated with land-use diversity (Factor 4). On the one hand, high development density means increasing the number and density of existing types of facilities; on the other hand, a more diverse land-use pattern requires more variation in and choice of facilities for various social groups residing in the neighbourhood (Kooshian & Winkelman, 2018; Ogra & Ndebele, 2014). In actual practice, both concepts should be implemented to achieve a compact urban development. However, the survey indicates an unequal relation. Factor 4 has a significantly higher 'very likely/likely' rate and a lower 'very unlikely/likely' rate than Factor 3, indicating that most people in Changsha would like to have a more diverse land-use pattern than higher density. Studies from Goel & Mohan (2020), Lin & Shin (2008), and Zhang (2004) partially reflect the survey results that population and development density and land-use diversity should not be the main contributions to travel behaviour changes in many dense and mixed-use Asian cities in India, China, or Taiwan. Nevertheless, considering that roughly 80% of the respondents believe that a more diverse land-use pattern is likely to change their travel behaviours, it also reflects the lack of diverse land-use patterns in Changsha at the current stage.

The last four factors examine the effect of walking- and cycling-friendly design (Factors 5 and 6) and car-friendly design (Factors 7 and 8) on people's neighbourhood travel behaviour. As shown in Figure 4.3, both optimising existing walking and cycling facilities and adding more walking and cycling routes get 76.6% 'very likely' and 68.09% 'likely' responses. They also get some of the lowest 'very unlikely/unlikely' rates, with 10.64% and 4.26% respectively. In comparison, adding more car routes and more parking spaces earn the highest 'very unlikely/unlikely' rates (48.94% and 44.68%). The results show that implementing a walking- and cycling-friendly design can increase the probability of people choosing to meet their everyday living needs in the neighbourhood, while implementing a car-friendly design does not help much. This coordinates with Cervero & Kockelman's (1997) opinion on appropriate neighbourhood design, requiring high walking and cycling accessibility within the neighbourhood. This should be accompanied by diverse land-use patterns to create a vibrant and sustainable neighbourhood. Because neighbourhood characteristics can be used to influence travel behaviour (Aditjandra *et al.*, 2012), it could reduce the possibility of travelling by car while guiding people to do more within-neighbourhood travel by increasing their access to viable neighbourhood facilities.

4.4 Research on the Overall Travel Behaviour and Residential Self-selection

4.4.1 Data Summary

As discussed above, there are two attributes defining whether people have a TOD lifestyle or not: they should mainly take the metro if they travelling in the city, and they should mainly travel in or around their neighbourhood to meet their basic living needs. The statistical results shown in Figure 4.4 demonstrate the proportion of people having both attributes, having only one, and having none. The results show that 11.3% of the respondents have both TOD attributes, while 15.9% of them have none. About 72.8% of respondents only have one of the attributes, while the vast majority among them travel in the neighbourhood for basic living needs but do not take the metro when travelling in the city.

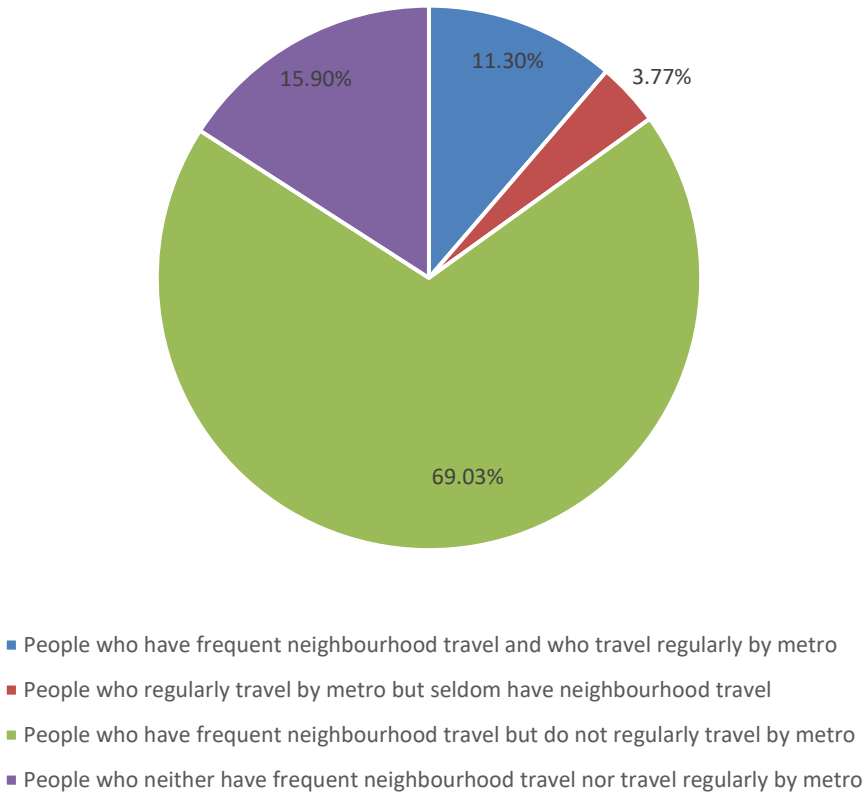

Figure 4.4. TOD attributes distribution in respondents

In terms of residential self-selection, a total of nine reasons have been provided, and respondents were asked to choose up to five reasons for their residential choices. People were asked the reasons they would select a particular neighbourhood if they were to move their residences, and their reasons for living in their current residences. These reasons contain both living conditions (living environment, housing prices, and layout) and the convenience of different travel modes, and people can provide additional reasons if the ones provided are not suitable. Table 4.5 shows the results of people's residential self-selection comparing their reasons for moving residences and for residing in their

current neighbourhood. The results show that 'good living environment' and 'close to workplace' are two of the heaviest-weighted reasons when people consider their new residences. Compared to people's reasons for living in their current residences, these two—along with 'close to a metro station' and 'convenient to a car park'—experienced a significant reduction in their weights, while 'close to a bus station', 'suitable housing price or rent', and 'suitable housing layout' remained stable. The weight of 'other' has significant increased in this comparison, with many saying that they have lived in their current residences since their childhood, or that their houses are allocated by their work units.

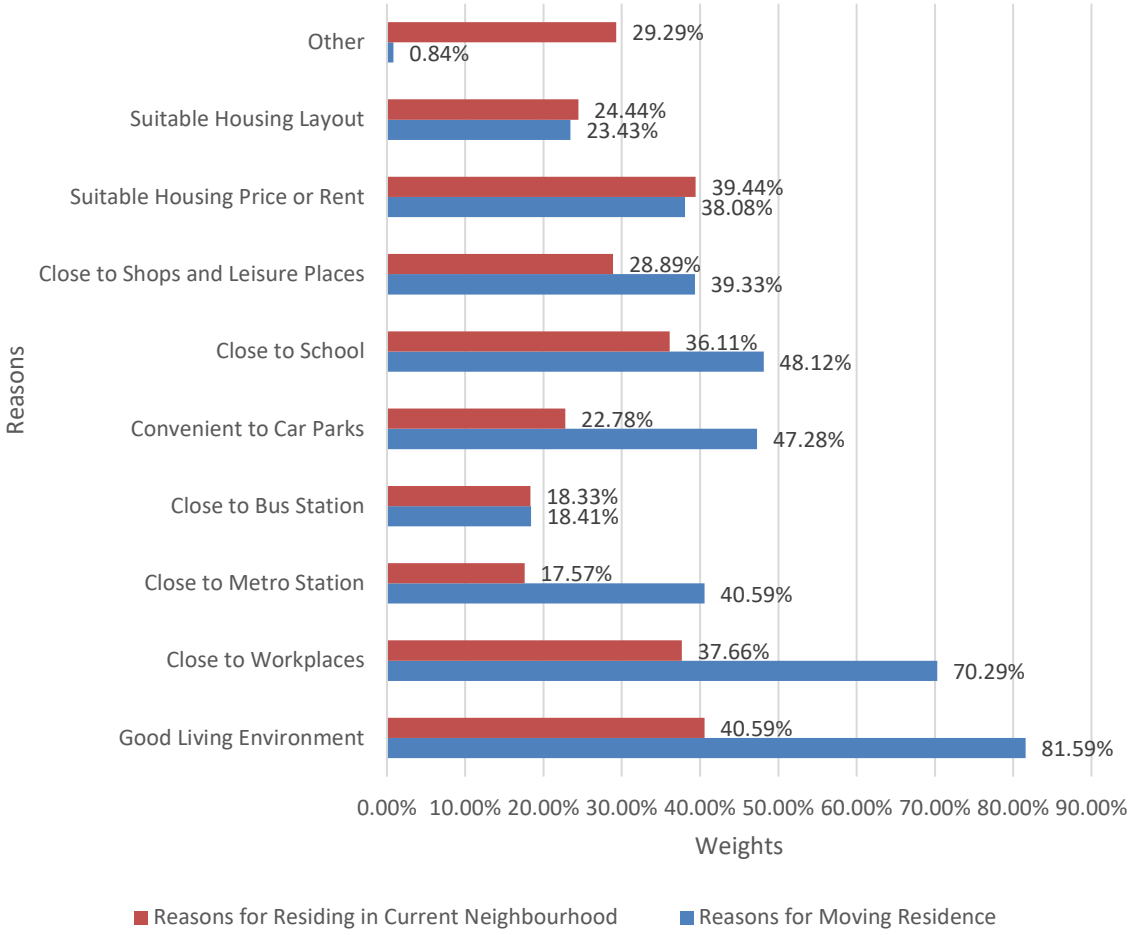

Figure 4.5. Results for people's residential self-selection

4.4.2 Discussion

As Figure 5.4 indicates, only around 11.3% of the respondents have the attributes of a TOD-style travel mode, and the direct reason is that only 15.06% take the metro as their main urban travel mode. In contrast, the vast majority (69.03%) do not use the metro as their main urban travel mode but mainly travel in or around the neighbourhood to meet their basic demands. As discussed previously, many Chinese cities, Changsha included, already have high density and diverse land-use patterns, which may lead to constant and active neighbourhood travel for many urban residents. Meanwhile, reflected in the low metro ridership, there is also a lack of development in the urban transit system due

to the relatively short time for economic development and city planning. It is worth noting that the metro may not be able to serve most of the urban travel needs because of its capacity limits. Taking London as an example, where the Underground (subway)/docklands light railway (DLR) only accounts for around 11% of daily trips (TfL, 2019: 41) due to the limited maximum capacity. This is one of the reasons TOD needs to promote neighbourhood travel after reducing the use of cars, that is, to reduce the need for long-distance travel and ultimately reduce the pressure of urban transit by allowing people to travel mainly nearby.

From the survey of people's residential self-selection, 'close to workplace' with over 70% of the weight, along with other significantly weighted factors ('close to school' and 'close to shops and leisure places'), indicating that most people preferring walking and cycling as their main commuting mode, and also tend to have their daily trips near their residences. Also, over 40% of respondents selected 'close to metro station', which may lead to the rise of metro ridership due to their residential choices, while nearly 50% also chose 'convenient to car parks', indicating that cars would still be the main travel mode. Overall, according to the attitude on people's residential self-selection, people in general tend to live in a neighbourhood where they can walk and cycle for most of their necessary trips, and many of them would like to take metro, though the car is still a significant consideration. However, the reasons people reside in their current neighbourhood tells a different story. Compared to their attitudes on residential choices, most of the factors experienced huge shrinkages. Since metro construction only began in the past decade or so, some people had to choose 'close to bus station' as one of the consideration factors before that, so they are likely to continue to select it as the main factor, which may explain why its weight remains stable. Similarly, 'suitable housing price or rent' and 'suitable housing layout' also remain stable, showing that people still put housing conditions before other factors. In 'other', many report that they have either lived in the same home since childhood or their houses were allocated by their work units. All of these reveal results similar to Chen *et al.* (2017), who found that Chinese people face heavy restrictions in housing choices.

5. Conclusions

5.1 Summary

This dissertation has identified and discussed several findings about the relationship between people's travel behaviours and TOD in Changsha. A total of 239 viable responses were collected through an online survey. The main objectives were as follows:

1. identify the relationships between sociodemographic and transport-related factors and people's tendency to use the metro for urban travel;

2. identify the changes needed in a neighbourhood to attract people to boost their neighbourhood travel; and

3. study how many people now have 'TOD lifestyles' in Changsha and understand their attitudes on residential self-selection.

The responses to these objectives are presented below.

5.2 Responses to Objectives

5.2.1 Objective 1

Around 15% of respondents take the metro as their primary mode of urban travel, according to the survey. Six factors (gender, age, income, car ownership, destination parking, and a viable metro station) have been examined using the binary logistic model. Factors directly linked to transport are more significant than other sociodemographic factors, which may only influence people's travel behaviour indirectly. People with a viable metro station near their residence are most likely to travel by metro, and there is also a certain degree of likelihood that people will take the metro if they do not own cars or if their destinations are not car parking-friendly. Basically, the results are mostly in line with previous studies. In contrast, the impacts of gender, age, and income are minimal, which might indicate, at least in Changsha, that the metro is not a travel mode with socio-discriminative attributes, which is not clearly reflected in older studies.

5.2.2 Objective 2

In this survey, 47 respondents were asked about the factors that could boost their neighbourhood travels, while a total of eight factors in terms of the Three Ds (density, diversity, and design) have been examined in this study. The findings indicate that the increase of density, especially population density should have a significant impact on diverting people's travel behaviour. Optimising car-friendly design in the neighbourhood is the least useful factor in changing people's habits. On the other hand, people could do more neighbourhood travel by encouraging land-use diversity and implementing non-car-friendly design. These results are different from previous studies based on Western countries, but they are basically consistent with those based in Asian contexts, except the aspect of diversity, which indicates Changsha's shortcoming with regard to diverse land-use patterns.

5.2.3 Objective 3

People's general travel behaviours and their residential self-selections were studied in this section. For the travel behaviours, only around 11.3% of respondents can be classified as 'having TOD-styling travel behaviours', while the majority tend to do neighbourhood travel but they do not use urban transit for their urban travels. When studying the factors considered in people's residential self-selection, in terms of selecting their current residences, just as previous studies found that Chinese have relatively large restrictions on their housing choices, most of them must focus more on suitable housing price and layout, or simply do not have many choices. The good sign is, however, that many respondents express a high interest in living in a neighbourhood with high walking, cycling, and transit accessibility if they were to consider moving into a new neighbourhood now.

5.3 Contributions and Policy Implementations

The study researched people's travel behaviour in Changsha, aiming to find whether people can develop a TOD-style travel behaviour after the construction of the metro. It has made a certain contribution in revealing the problems with transport planning of Changsha. The study shows that metro is still not the main travel mode in Changsha, while cars are still the major travel mode for over half of the respondents. This may be due to a lack of car restrictions and to public transport-focused urban planning. Considering only around one-third of respondents can easily access the metro station near home, metro service coverage should be considered insufficient. By making the metro station more accessible while limiting car parking, people can be pushed to use the metro system. In terms of TOD neighbourhood planning, the Three Ds are also important in the context of Changsha. However, the study noticed the minor effects of density in the improvement of the neighbourhood, which is partly echoed by studies performed in Asian cities, but diversity still plays a role in this process, showing the deficiencies in land-use diversity in Changsha compared to other Asian cities.

Therefore, the following points should receive the focus in future transport policy implementation in Changsha. Fundamentally, the metro service should continue to expand coverage. It could be achieved both through improving the accessibility to metro stations and through increasing the density of the metro lines and stations. For neighbourhood planning, planners should focus more on improving land-use diversity and enhancing walking and cycling facilities; these can help divert people's travel behaviour more from automobile travel to neighbourhood travel, and can relax the pressure on the metro system. Policymakers should also introduce more policies that relieve the pressure to purchase houses and encourage people to consider residences in a TOD neighbourhood.

5.4 Limitations of This Study

As mentioned previously, the metro is still a relatively new thing in Changsha, and it only started operation in 2014. As a result, there may not have been enough time for people to change their travel behaviour. It is necessary to carry out further study on this topic in Changsha when the metro will have had a deeper influence on people's lives. Future research is also needed for studying the proportion of urban travel versus neighbourhood travel. Instead of the equal distribution of these two travel behaviours in most residents' daily trips, in real life, neighbourhood travel may be the dominant one, and may account for the majority of people's daily trips, while urban travel should take the smaller share. Moreover, future research should consider enlarging the sample size as well.

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Appendix 1: Self-Completion Questionnaire

CHANGSHA PEOPLE'S TRAVEL BEHAVIOUR SURVEY 2020

Greeting. We are carrying out some analysis of people's travel behaviour in Changsha. The results will be very useful in our research and We would be very appreciated if you can help. Please answer the following questions according to your daily travel behaviour. All responses are anonymous and will be treated confidentially.

Q1. What is your gender?
□ Male
□ Female

Q2. Please state your age?

_____

Q3. Please state your annual income (Unit: Chinese yuan)?

_____

Q4. What is your most frequently used urban travel mode?
□ Private Car
□ Bus
□ Metro
□ Walking and Cycling
□ Other

Q5. Do you own cars?
□ Yes
□ No

Q6. Are most of your destinations allowed and convenient to park?
□ Yes
□ No, most are not allowed
□ No, most are allowed but inconvenient

Q7. Is there a metro station near your house that can be accessed by foot or bicycles easily?
□ Yes
□ No, there is a metro station near my house but hard to access by foot or bicycles
□ No, there is no metro station near my houses

Q8. Do you mostly travel in or around your neighbourhood to meet most of your basic living needs (e.g. shopping, having meals, entertaining, etc,)?
□ Yes
□ No
(Skip to Q10 if Q8=Yes)

Q9. What changes the neighbourhood should have to attract you to travel mostly in or around your neighbourhood for your basic living needs?

	Very Unlikely	Unlikely	Neutral	Likely	Very Likely
Increase local population density					
Increase local car density					
Increase local development density					
More diverse land-use patterns					
Optimise existing walking and cycling facilities					
Add more walking and cycling routes					
Add more car routes					
Add more parking spaces					

Q10. Which of the following factors you may consider the most if you need to move to a new neighbourhood? Select no more than 5 factors.

□ Good Living Environment
□ Close to Workplaces
□ Close to Metro Station
□ Close to Bus Station
□ Convenient to Park Cars
□ Close to School
□ Close to Shops and Lersure Places
□ Suitable Housing Price or Rent
□ Suitable Housing Layout
□ Others (Please state): _____

Q11. Which of the following factors you considered when choosing your current residence? Select no more than 5 factors.

□ Good Living Environment
□ Close to Workplaces
□ Close to Metro Station
□ Close to Bus Station
□ Convenient to Park Cars
□ Close to School
□ Close to Shops and Lersure Places
□ Suitable Housing Price or Rent
□ Suitable Housing Layout
□ Others (Please state): _____

Thank you for your completing this survey. The results will be very useful to us in our research

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

DEPARTMENT/SECTION **THE BARTLETT SCHOOL OF PLANNING**

LOCATION(S) **CHANGSHA, CHINA**

PERSONS COVERED BY THE RISK ASSESSMENT **Dingrui Chen**

BRIEF DESCRIPTION OF FIELDWORK Online Survey

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.	Examples of risk: adverse weather, illness, hypothermia, assault, getting lost. Is the risk high / medium / low? Low

CONTROL MEASURES	**Indicate which procedures are in place to control the identified risk**
	work abroad incorporates Foreign Office advice
X	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	Examples of risk: loss of property, loss of life

None

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 *lone interviews.*	Examples of risk: difficult to summon help. Is the risk high / medium / low?		

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.*	Examples of risk: injury, asthma, allergies. Is the risk high / medium / low? None

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	X	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	**X**	**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?

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:

X	I the undersigned have assessed the activity and associated risks and declare that there is no significant residual risk
X	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**

SIGNATURE OF SUPERVISOR **Mengqiu Cao** DATE 29 May 2020

FIELDWORK 5 May 2010