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Special Issue: Urban Transport and Social Inequities in China: New Research Agenda and Policy Actions

Understanding Travel and Differential Capabilities and Functionings in Beijing

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Understanding Travel and Differential Capabilities and Functionings in Beijing

Abstract

The social impacts of transport systems and new transport infrastructure have often been overlooked and undervalued, partly because the relationship between transport and social equity is indirect and difficult to quantify. Researchers have usefully investigated the relationship between transport and social exclusion, focusing on aspects such as access to opportunities and activities by different population cohorts such as income, class, age, ethnicity and gender. The analysis has focused on addressing the imbalance in the distributional effects of transport provision and accessibility planning has often been a central tool in analysis. This paper seeks to build on the aforementioned research, employing Amartya Sen's Capabilities Approach as a theoretical framework to explore how an individual's capabilities and functionings differ in relation to transport. Beijing is used as a case study, with analysis from three stations on the Beijing subway line 1 and its extension to the Batong line, namely Guomao, Sihui and Tuqiao. Martha Nussbaum's Central Human Capabilities Approach is used to frame the analysis. The results show that functionings and capabilities differ according to an individual's socio-economic characteristics and geographical location, meaning that both the opportunities to participate in life and also the actual activities themselves differ. This is an important distinction that the Capabilities Approach offers, and it is useful to consider if the potential for achieving improved social equity is to be realised.

Keywords

Transport; social equity; travel equity; the Capabilities Approach; Beijing.

Highlights

- The Capabilities Approach is applied in transport planning.
- A framework for understanding multi-dimensional social impacts is developed, including issues of life, bodily health, emotion and affiliation.
- Comparisons are made for capabilities and functionings across socio-demographic characteristics and location.

1. Introduction

When considering issues of transport and social equity in China, it is useful to refer back to Confucius (551 BC-479 BC), an ancient philosopher and founder of Confucianism, from Lu (present day Shandong) in China. Confucius encouraged the cultivation of knowledge, sincerity, personal and governmental morality, distributional equity, and correctness of social relationships. He asserted that: "[I]f there is equality in distribution, there will be no poverty; if there is harmony in society, there will be no under-population, and if there is security, there will be no subversion" (Muller, 1990, p.1).

It is this principle of benevolence which is important in social equity; where social equity is seen as the fair access to opportunities, livelihood, education and resources. Similarly, in ancient Western thought, Aristotle (350 BC) sees human flourishing (eudemonia) as the highest aim in human thinking, beyond the more conventional but limited focus on economic growth. Social justice is itself distinguished as the fair and just relation between the individual and society, including the distribution of wealth and opportunities (Mella Lira and Hickman, 2017).

In transport planning, accessibility is most often used as the metric to judge the level of social equity associated with a major infrastructure project (Geurs and Van Wee, 2004; Van Wee and Geurs, 2011; Lucas, 2012; Lucas et al., 2016; Cuthill et al., 2019). Hansen (1959, p.73), for example, provides the classic definition of accessibility as: "the potential of opportunities for interaction […] a measure of the intensity of the possibility of interaction rather than just a measure of the ease of interaction". Distinctions have been made between person and place-based accessibility, examining the attributes of both individuals and places (Martens, 2017) and in examining the contributions of different transport systems to the levels of access for different population groups (Geurs and Van Wee, 2004; Lucas, 2012; Martens, 2017; Social Exclusion Unit, 2003).

This paper builds on the previous analysis to examine the difference between the opportunities to travel and engage in activities and individuals' actual travel and engagement in activities. It uses the Capabilities Approach (CA) (Nussbaum, 2003; Sen, 1999, 2009) to help understand how improving physical accessibility might only take us so far in encouraging participation in societal activities. CA is emerging as a conceptual framework to be used in transport planning (Beyazit, 2011; Ryan et al., 2015; Hananel and Berechman, 2016; Martens, 2017, Hickman et al., 2017, Cao and Hickman, 2019b), but there have been few attempts to test the approach empirically.

The aims and contributions of the paper are to put forward an approach to using CA in transport, in particular by: (1) suggesting multi-dimensional social indicators that might be used to assess social equity in relation to transport; and 2) examining how these differ by socio-demographic characteristics and neighbourhood.

The paper is structured as follows: a discussion on CA and its potential application within

transport; an overview of the selected case study in East Beijing; data and methodology used in the analysis; results of the modelling analysis and commentary; and, finally, reflections on the theoretical and practical implications of the research.

2. The Capabilities Approach and its Potential Application in Transport

The CA was developed by Sen (1985, 1999, 2009), building on thinking from Rawls (1971) which emphasised maximising the benefits for least-advantaged groups after basic equal rights have been secured in a society. Sen describes the CA as "a general approach, focusing on information on individual advantages, judged in terms of opportunity rather than a specific 'design' for how a society should be organised" (Sen, 2009, p.232). In addition, Sen (2009, p.233) emphasises that the: "[CA] focuses on human life, and not just on some detached objects of convenience, such as incomes or commodities that a person may possess, which are often taken, especially in economic analysis, to be the main criteria of human success". Therefore, the CA is not only concerned with the consequences of social justice for human development, but can also help to understand people's ability to achieve something beyond what they have already achieved (ibid.).

The central concepts used in the CA, as defined by Sen (1999, p. 75), are:

- Capabilities: the "alternative combinations of beings and doings that are feasible to achieve", i.e. what real opportunities are available for people to do and to be;
- Functionings: the various things a person values being and doing"; and realised functionings represent what a person actually does.

This distinction can be useful as it allows us to understand why certain levels of infrastructure or accessibility may not be used by all – it can be viewed as an analytical tool complementary to accessibility planning (Hickman et al., 2017; Cao and Hickman, 2019a). Particular cohorts or 'vulnerable' people might need additional resources to help them to reach the same or a similar level as another person (Sen, 1985). For example, a low income person may need some form of subsidy to use the expensive train or subway, or a different education or set of skills to access the high quality job at the end of the new public transport route. In addition, the CA emphasises beings and doings. In the transport case, this extends beyond travel and consumption of activities to the development or flourishing of a person and even including their duties and obligations.

Robeyns (2006) further describes a person's capabilities as the genuine freedoms or opportunities they have to realise their functionings, the latter including being safe, being mobile, and being well-educated, etc. Walker (2006, p.165) expands as follows:

"[a] capability is a potential functioning; the list of functionings is endless [,] … The difference between a capability and functioning is like one between an opportunity to achieve and the actual achievement, between potential and outcome. For example, the capability for mobility and actually moving around, the capability to be literate compared to actually reading, or the

capability to be well-educated and acting and being a well-educated person. All a person's capabilities together comprise her capability set, 'her real or substantive freedom to be and do what she wants' (Walker, cited in Robeyns, 2003, p.544)".

Capabilities are the most difficult to apply in transport, and we interpret capabilities in this paper as perceived opportunity or ideal accessibility. This is then compared to functionings, which are the realised activities (see further discussion in Hickman et al., 2017; Cao and Hickman, 2019b, Cao, 2019). Capabilities are indeed more complex than perceived individual opportunity or desire, involving structural constraints on freedom, opportunities, values, desires and choices, which together result in real opportunity and an individual's capability set.

Nussbaum (2003) claims that the idea of 'freedom' argued for by Sen seems too ambiguous to specify and apply in practice. It can be argued that, in reality, freedom covers both positive and negative impacts (e.g. positive and negative liberty); at the same time, some freedoms can be restricted by others, and some freedoms are more important than others. There are barriers to using accessibility, such as income or other factors, and it is important to be aware one person's freedom can limit another person's freedom. A subway at full capacity, for example, may mean some people do not wish to use it at peak periods, indeed it may be very difficult for those with mobility difficulties. Hence there are complex factors at play that impact on actual travel and participation. Sen's discussion of the CA is, however, problematic in not providing a clear explanation of the extent to which the equality of resources should be achieved (Nussbaum, 2003); nor does it clarify what the threshold between a just and unjust society ought to be (ibid.). In other words, the connection between an individual's actual functionings and capabilities remains vague.

The approach taken in Table 1 is to show how fundamental entitlements (drawing on Nussbaum, 2003) might be understood and applied in the transport context, i.e. which central human capabilities are necessary to ensure that citizens have a comfortable livelihood and a basic level of social engagement. Nussbaum (2000, 2003, 2011) states that 'plural capabilities' should be used instead of a 'single capability', as the quality of human life and social participation is multi-dimensional, and it can be seen that this applies in transport. This addresses the first aim of the paper, offering a set of multi-dimensional social indicators which could be used in transport appraisal. For example, there are important issues of safety, which relate well to life; active travel to bodily health; engagement in a range of social activities and interaction to emotion and affiliation. Although the mapping of transport indicators onto categories is open to interpretation, and there is some overlap between categories, the purpose here is to develop a list of transport indicators that can help us assess wide-ranging social impacts related to transport projects, travel and participation in life.

Table 1. Nussbaum's Central Human Capabilities and Application in Transport Planning

Central Human Capability Category	Indicator Being able to:	Application in Transport Planning Being able to:
1. Life	Survive and not to die prematurely.	• Travel safely with minimal risk of accidents • Access food and clothes shopping
2. Bodily Health	Live with a good standard of health care, adequate food and drink, sleep, and shelter.	• Access daily activities • Travel actively, such as by walking, cycling and public transport • Access a general practitioner (GP) or hospital
3. Bodily Integrity	Access mobility and to be protected against criminal offence, injury, assault and threat.	• Move from one place to another without fear of injury, assault, or threat
4. Senses, Imagination, and Thought	Feel, understand, imagine, speak and think in a truly humane way, while undertaking basic daily activities (e.g. exercising freedom of choice regarding religion, literature, and music, etc.) and work and live without interruption by others; access training and education.	• Access employment, education and training opportunities • Access cultural and entertainment opportunities • Produce good ideas, imagine and reflect on one's work and daily life, including reading, listening to music, and accessing Wi-Fi whilst travelling
5. Emotions	Rely on things and other people beyond ourselves; enjoy activities and participation; love, grieve and care for others.	• Engage in a wider range of social activities and social interaction • Travel and/or meet up with family and friends • Access help during the journey, if required
6. Practical Reason	Exercise freedom of religious and other beliefs without punishment; reflect and be proud of achievements gained in life.	• Use different means of transport without experiencing any discrimination • Access a wide range of cultural activities
7. Affiliation	Live equally and communicate with other people in a society without any discrimination or unjust judgment based upon differences in gender, race, ethnicity, national origin, sexual orientation, and religion; vulnerable groups are cared for by others.	• Engage in a wider range of social activities and interaction • Use different means of transport without experiencing any discrimination
8. Other Species	Peacefully coexist with other species in the natural world without destroying their living environment to fulfil human demands.	• Use different modes of transport without causing any adverse effects such as environmental degradation and noise pollution • Use renewable and clean energy rather than fossil fuels for travel
9. Play	Enjoy recreational activities, have fun, play and laugh.	• Engage in a wide range of social activities and interaction • Play and have fun
10. Control Over One's Environment	Have equal opportunities to access employment and work with others; efforts and achievements within the workplace are respected and recognised by others; have access to a home; vote and be elected and participate equally in politics and the governance of people's lives.	• Access a range of employment opportunities • Afford daily travel costs (i.e. only spend a low proportion of total household income on travel) • Engage in political participation

(Developed by the authors, drawing on Nussbaum, 2000, 2003, 2011, also see Cao and Hickman, 2019b)

Note: The central human capability categories and indicators are from Nussbaum, and their application in transport planning is from the authors.

3. Case Study and Methods

3.1 Case Study Context

Beijing is the capital of China, with a land area of 16,410 square kilometres. It has a population of 21.71 million permanent inhabitants and 8.23 million permanent migrants (2015), as well as being one of China's four directly-controlled municipalities (the others being Shanghai, Tianjin, and Chongqing) (BMBS, 2016; BTI, 2016). The city has experienced rapid urbanisation which has had significant effects on the quality of life for millions of people since the 1980s (Guo, 2014). This includes social inequity issues, particularly between local residents with Beijing hukou and migrants without Beijing hukou[1] (Zhao, 2012, 2013b). For instance, numerous migrants, especially those without higher-education or affluent income, continue to be treated as 'rural people' leading to social discrimination due to the hukou mechanism, which means they often lack comparable levels of accessibility to public facilities and services to local urban residents who hold Beijing hukou. However, very few studies have investigated the effects of transport-related social injustice issues for neighbourhoods near subway stations in China (Li and Zhao, 2017).

The analysis focuses on the urban and urban fringe area in East Beijing, in neighbourhoods surrounding three stations on Beijing's subway line 1 and its extension to the Batong line (Guomao, Sihui and Tuqiao). Guomao and Sihui opened in 1999 and Tuqiao opened in 2003. A relatively large share of households in Guomao belong to the higher-income bracket; middle-income people are more likely to be found in Sihui; while lower-income people are more prevalent in Tuqiao (51.1% of Guomao respondents' monthly income during the past 12 months was over 10,000 Chinese Yuan, compared to 34.7% in Sihui and only 7.7% in Tuqiao); hence there are different income levels in the three neighbourhoods.

3.2 Data and Methods

Figure 1 shows the location of each of the three station survey catchment areas, defined as a 1km radius from the station in East Beijing, which equates to approximately a 15-minute walk. Face-to-face surveys[2] were conducted with 2,336 residents in 2016, comprising 846, 817 and 673 respondents living in the station catchment areas of Guomao, Sihui and Tuqiao respectively. A simple random sampling approach was used to select (Fink, 2003; Valliant et al., 2013) and interview participants who were walking either near the station or in the communities within the station catchment area. A systematic sampling approach was used to select households (Fink, 2003; Pfeffermann and Rao, 2009) and carry out interviews in the communities within the station catchment area. Each face-to-face survey lasted approximately 15 minutes on average. Descriptions of the variables used in the analysis are provided in Table 2.

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[1] Hukou refers to the household registration scheme used in China and is used to identify a person as resident in an area. Benefits such as education, health care and retirement pensions are particularly related to an urban local hukou, and migrants do not qualify for these, hence there is much inequity in the system.

[2] Although questions regarding 'capabilities' and 'functionings' could seem rather abstract to some respondents, the interviewers explained the meanings of the relevant questions, and the terminology, to ensure that respondents understood them. A pilot survey was also used to check understanding (Cao, 2019).
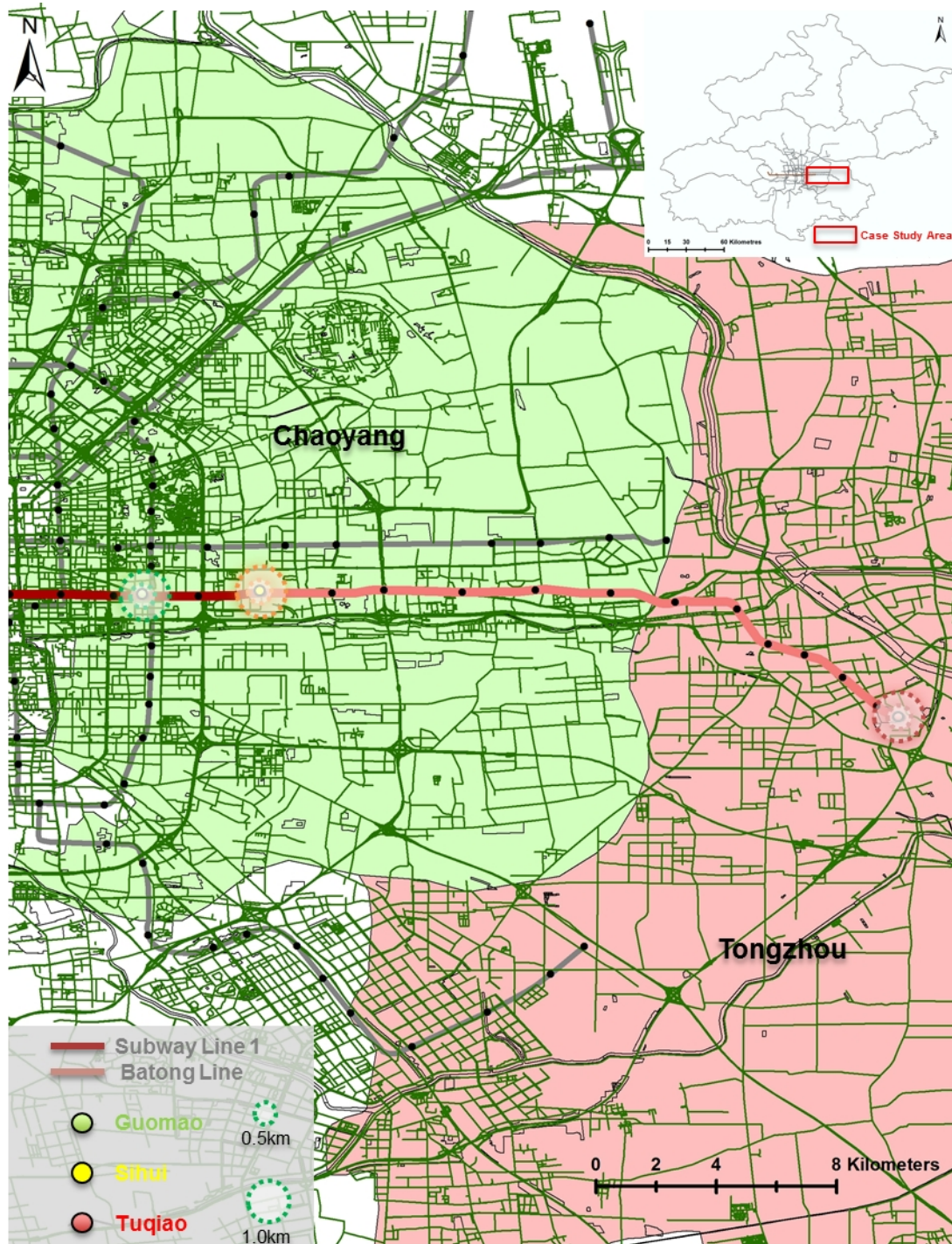
Figure 1. Case Study of Urban East Beijing (Source: the Authors)

Table 2. Descriptions of Variables

Categories	Variable Names	Description (Measure and Value)	Data Type
Demographics			
Gen	Gender	1(female); 0(male)	Categorical
Edu	Education	1(first degree or above); 0(otherwise)	Categorical
Age	Age	1(18-24); 2(25-34); 3(35-44); 4(45-54); 5(55-64); 6(65 or over)	Ordinal
Hst	Housing tenure	1(owned); 0(otherwise)	Categorical
Mas	Marital status	1(married); 0(otherwise)	Categorical
	Hukou status		Categorical
Urh	Urban *hukou*	1(urban *hukou* holders - including Beijing and other cities); 0(otherwise)	Categorical
Luh	Local urban *hukou*	1(Beijing urban *hukou* holders); 0(otherwise)	Categorical
Inp	Incumbent population	1(moved to the area before the corresponding subway stations were opened); 0(otherwise)	Categorical
Socio-economics			
Emp	Employment	1(if employed/self-employed); 0(otherwise)	Categorical
Dri	Driving Licence	1(yes); 0(otherwise)	Categorical
Cao	Car Ownership	1(yes); 0(otherwise)	Categorical
Monthly household income			
Hye	In the year 1999/2003	Monthly household gross income in Chinese Yuan: 1(<2,000); 2(2,000-4,000); 3(4,001-12,000); 4(12,001-20,000); 5(20,001-40,000); 6(40,001-60,000); 7(>60,000)	Ordinal
H12	During the past 12 months	Monthly household gross income in Chinese Yuan: 1(<2,000); 2(2,000-4,000); 3(4,001-12,000); 4(12,001-20,000); 5(20,001-40,000); 6(40,001-60,000); 7(>60,000)	Ordinal
Travel time			
Tmw	Main transport mode for work	Total amount of time (minutes)	Continuous
Tmnw	Main transport mode for non-work activities	Total amount of time (minutes)	Continuous
Capabilities & Functionings			
Life			
LItrs	C&F_travel safety (accidents)	Index of functionings/capabilities	Continuous
LIshp	C&F_access grocery/clothes shopping	Index of functionings/capabilities	Continuous
Bodily Health			
BHhos	C&F_access hospitals	Index of functionings/capabilities	Continuous
BHact	C&F_active travel	Index of functionings/capabilities	Continuous
Bodily Integrity			
BItrs	C&F_travel safety (violent assault)	Index of functionings/capabilities	Continuous

Senses, Imagination, and Thought			
	SItre	C&F_access training and education	Index of functionings/capabilities	Continuous
	SIcri	C&F_creativity and imagination	Index of functionings/capabilities	Continuous
Emotions			
	EMtrv	C&F_travel and visit family/friends	Index of functionings/capabilities	Continuous
Practical Reason			
	PRcua	C&F_access cultural activities	Index of functionings/capabilities	Continuous
Affiliation			
	AFreh	C&F_respect and get help	Index of functionings/capabilities	Continuous
Other Species			
	OSend	C&F_against environmental degradation	Index of functionings/capabilities	Continuous
Play			
	PLler	C&F_leisure and recreation	Index of functionings/capabilities	Continuous
Control Over One's Environment			
	COwoo	C&F_seek work opportunities	Index of functionings/capabilities	Continuous
	COtra	C&F_travel affordability	Index of functionings/capabilities	Continuous
	COpop	C&F_political participation	N/A	

Note:	C&F = Capabilities and Functionings.
	Developed from Lorgelly et al. (2008).
	'Not applicable' responses in the survey research are treated as missing values in statistical terms. Therefore, the sample sizes used in the analysis are 2,127.

Applying the concepts of capabilities and functionings is not straightforward, particularly in the case of capabilities – the real opportunities that people have (see further discussion in Hickman et al., 2017). Capabilities are a measure of opportunity to participate in life and as such reflects many dimensions. In this research (also see further details in Cao, 2019), the following form of question was asked in relation to different activities and capabilities, such as access to the theatre, doctor, church, family and friends, etc.. The distinction is focused on the ability to reach an activity based on individual viewpoint or desire (capability), with a perceived full availability of transport, relative to actual activity and availability of transport (functioning). This encourages respondents to think about their substantial freedoms and potential opportunities in relation to transport and activities (i.e. what the person is substantively free to do using the current transport networks), This might be similar to accessibility levels, but modified according to personal circumstances or aspirations. In practice, it is difficult for respondents to understand and apply the capabilities concept, and we tested different questions with individuals in a pilot survey (Cao, 2019). This was found to be the most easily understood interpretation focused on individual desire. The capabilities concept can be further assessed in future research to help understand some of the important factors affecting real opportunities, including the political and cultural context, availability of infrastructure, activities on offer, and constraints such as cost, abilities and aspirations.

Consider transport factors only, and how much do you agree with the following statements on a scale from 0 - 5 where:

0	*1 1.5 2 2.5 3 3.5 4 4.5 5*
N/A	*Low* ▰▰▰▰▰▰ *high*

a. Capabilities	***Your expected opportunities for travel and activities*** *(i.e. your wishes/expectations)*
VS.	
b. Functionings	***Your everyday travel and activities*** *(i.e. your current situation)*

Type I:[3]

*Example (EMtry): Within Beijing, I would be able to **visit my family or meet up with friends**:*

	0	*1 2 3 4 5*
a. **Ideally** - if I could use whatever form of transport I wanted	N/A low	▰▰▰▰▰ high
b. **In reality** - based on the availability of transport modes on a day-to-day basis		▰▰▰▰▰ high

To measure the differences between capabilities and functionings by individual socio-demographic characteristics, the basic test statistic employed is an F-test. This method draws on Lorgelly et al. (2008) who use a similar approach to test inequalities for individual capabilities across different population groups enduring poor health in Glasgow. In the

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[3] Type I consists of LIshp, BHhos, SItre, EMtry, PRcua, PLler, COwoo, and COpop (see Table 2).

transport context, it is assumed that the levels of capabilities, functionings and/or the gap between them are all representations of 'travel equity'. The further these differ between population groups, the higher the value of the variability in the numerator of the F-statistic (see Equation 1). Hence we see similar scores in capabilities, functionings and the difference between these as representing an equitable situation.

$$F\ value = \frac{\sum_{i=1}^{\mu} n_i (\bar{Y}_i - \bar{Y})^2 / (\mu - 1)}{\sum_{i=1}^{\mu} \sum_{j=1}^{n_i} n_i (Y_{ij} - \bar{Y}_i)^2 / v} \tag{1}$$

Where:

- $\bar{Y}_i$: the sample mean in the ith group
- n_i: the number of observations in the ith group
- $\bar{Y}$: the overall mean of the sample size
- μ: the number of groups
- Y_{ij}: the jth observation in the ith out of μ groups
- n: the overall sample size
- v: degrees of freedom under the null hypothesis[4] (i.e. n - μ)

There are three sets of categories in the model shown in Table 3, namely: gender; household income; and incumbent population, with capabilities and functionings tested by these. Multicollinearity is also tested using the variance inflation factors (VIF) and tolerance statistics (Field et al., 2012; Field, 2013). For the current model, the VIF values are all less than 3 below the required threshold (Bowerman and O'Connell, 1990; Myers, 1990) and the tolerance statistics are all well above 0.2 (Menard, 2002), which suggests that collinearity is not a problem in this model.

To test whether there are any spatial differences between capabilities and functionings in relation to the different neighbourhoods around the three station catchment areas, multinomial logistic regression (MLR) is applied. This method draws on Shen and Wu (2013), who use MLR to examine the spatial differences between three districts categorised as: white-collar suburb; migrant suburb; and suburban new town in Songjiang, Shanghai. Similarly, Zhao (2013a) employs a multinomial logit model to examine the impact of urban form on individual workers' commuting patterns in Beijing. The station catchment area is used as the outcome variable (see Equation 2) and it is assumed that if the odds ratio (OR) is more than 1 (or less than 1, i.e. OR < 1 indicating a negative coefficient of estimate), the greater the likelihood of larger differences in transport-related social inequity between different neighbourhoods.

$$\eta_{ij} = log\frac{\pi_{ij1j2}}{\pi_{ij}} = \begin{cases} "1", \ \eta_{ij1j2} = \begin{cases} \eta_{ij1} = b_0 + b_i x'_i + e \\ \eta_{ij2} = b'_0 + b'_i x'_i + e' \end{cases} \\ "0", \hspace{3.5cm} \eta_{ij} = 0 \end{cases} \tag{2}$$

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[4] In this case, the null hypothesis is that there are no differences between capabilities and functionings for the potential groups of individuals' transport-related social justice.

Where:

- η_{ij}: log-odds of Sihui vs. Tuqiao and Guomao vs. Tuqiao, by the indicators

- j: $j \in Z^+$ (in the case, $j = 1, 2, ..., J-1$[5])

- J: in the case of $J=3$ categories, for instance, we contrast categories "1" vs. "3" and "2" vs. "3"[6]

- i: $i = 1, 2, ... n$

- b_0 / b'_0: an intercept value

- b_i / b'_i: a vector of regression coefficients

- x'_i: such as gender, education, age, ... , different indicators of capabilities and functionings, etc.

- e / e': residuals

The results of the MLR are provided below, indicating the statistical significance of the differences between the three different station catchment areas. Overall, many variables appear to be fairly strong in differentiating the three areas, as indicated by the large χ^2 statistic and the relatively high Cox and Snell's R^2 (0.583) and Nagelkerke's R^2 (0.657), which indicates a high goodness of fit of the model in Table 4 (see Cox and Snell, 1989; Nagelkerke, 1991).

4. Modelling Findings

4.1 Differences by Socio-Demographic Characteristics

The first hypothesis is that there are differences between capabilities and functionings in terms of transport-related social equity for the groups of individuals. Even though people may have similar levels of accessibility from where they live to the nearest local subway stations, there still may be differences in use of the transport system and access to activities. Fourteen transport indicators are explored, each with dimensions of capabilities and functionings. This is a simplification of the full possibilities available under Nussbaum's (2003) central human capabilities framework and other indicators could also be explored in further work. Table 3 gives summary test statistics for differences relative to the socio-demographic characteristics of gender, household income and incumbent population. There are significant differences across a number of the indicators, for both capabilities and functionings, as marked with asterisks.

There has been a growing volume of literature on gender differences in travel behaviour over the past few decades (such as Giuliano, 1979; Turner and Fouracre, 1995; ADB, 2013; Thynell, 2016; Sultana and Mateo-Babiano, 2017) according to different socio-economic characteristics; different transport modes used for the journey to work; personal safety issues and affordability. There are highly significant differences (p<0.001) by gender (see column 2 of Table 3) for 'accessing training and educational institutions' (capabilities and functionings); 'creativity and imagination' (capabilities); and 'accessing cultural activities' (capabilities and functionings). There are no identifiable significant differences by gender for access to work. However, females appear to have higher capabilities and functionings for access to family and friends; cultural activities; and being able to get help. This is similar to findings from Robeyns (2002), who also

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[5] The $J – 1$ multinomial logistic equations contrast each of the categories $1, 2, … J – 1$ with category J.

[6] In this case, the missing contrast between categories "1" and "2" can be obtained and calculated in terms of the other two. For example: $log\frac{\pi_{ij'1}}{\pi_{ij'2}} = log\frac{\pi_{ij'1}}{\pi_{ij'3}} - log\frac{\pi_{ij'2}}{\pi_{ij'3}}$

asserted that females tend to meet up with their friends more frequently than males, and that women are also more likely to seek help from others. Figures 2 and 3 summarise the data to show that women are more likely to have higher levels of capabilities and functionings than males particularly in terms of: 'travel and visit family/friends'; 'leisure and social activities'; 'access cultural activities'; and 'access training and education', a finding which contributes to the existing literature on transport-related gender differences.

However, Robeyns (2003) asserted that on average, males are still likely to be more active in the labour market than females and occupy more highly-skilled and higher-status jobs. Although the indicator, 'seeking work opportunities', was not statistically significant in the model, the results show that females had lower average scores on capabilities compared to males.
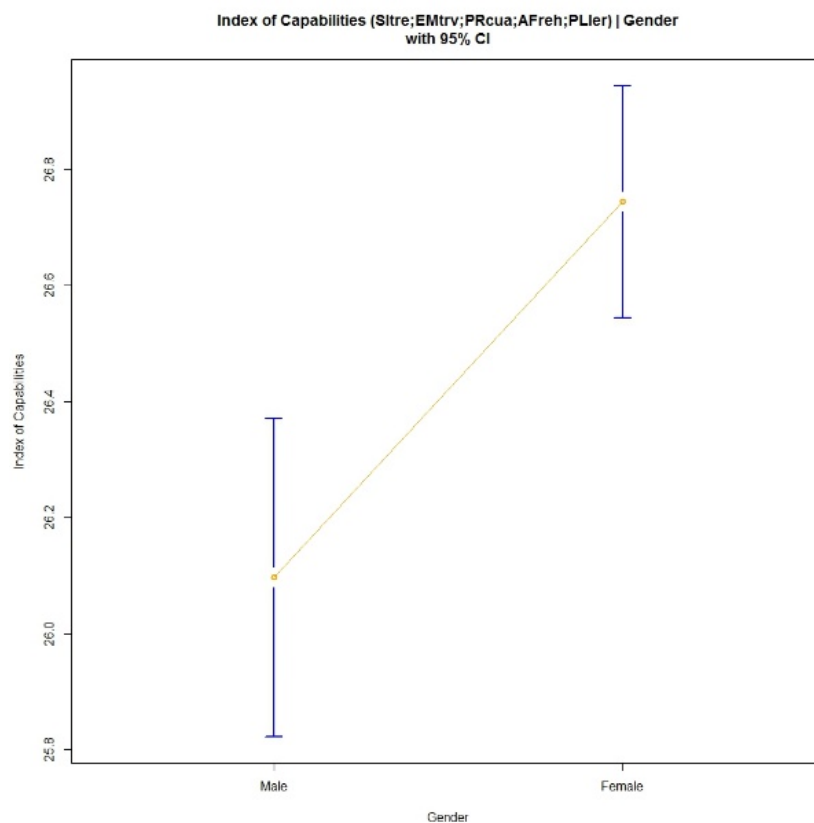
Figure 2: Mean Plots of Index of Capabilities for Gender Difference
(including: access training and education – SItre; travel and visit family/friends – EMtrv; access cultural activities – EMtrv; get help; leisure recreation – EMtrv)
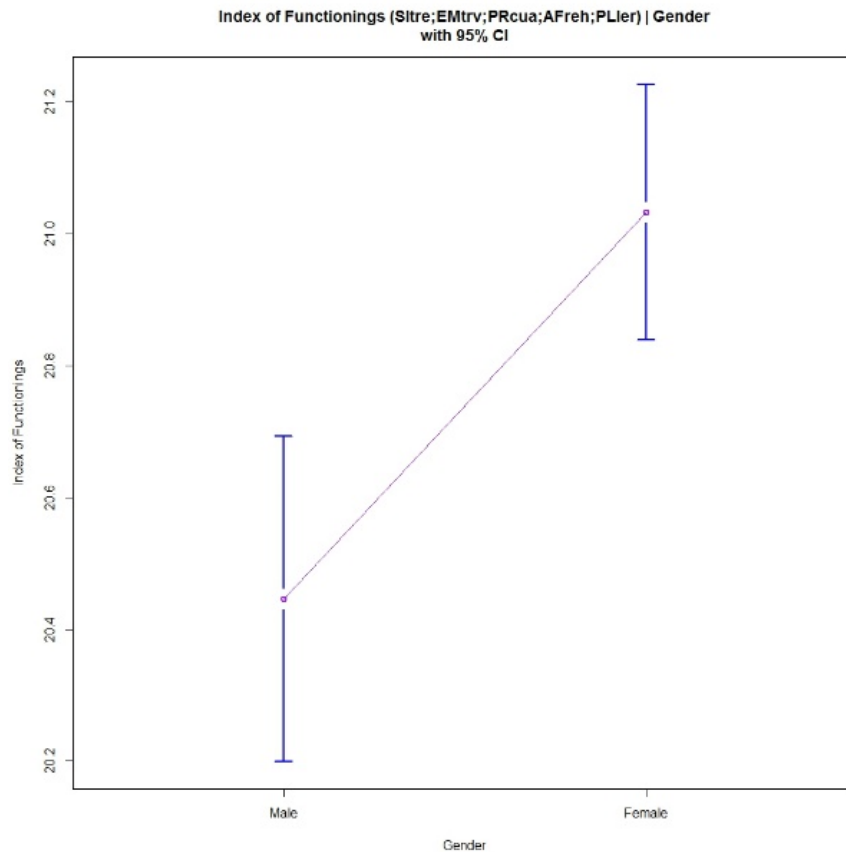
Figure 3: Mean Plots of Index of Functionings for Gender Difference
(including: access training and education – SItre; travel and visit family/friends – EMtrv; access
cultural activities – EMtrv; get help; leisure recreation – EMtrv)

The differences by income groups, for annual household incomes during the past 12 months, show that almost all of the indicators display highly statistically significant differences (see column 3 of Table 3). In other words, there are strong differences in respondents' capabilities, functionings and the gap between them for issues such as travel safety; access to grocery and clothes shopping; hospitals; active travel; safety whilst travelling; access to training and education; creativity and imagination; visiting family and friends, etc., across different income groups. This is consistent with previous research, which has shown that higher income groups are more likely to have higher rates of participation in various key life activities and are least likely to experience social exclusion compared with lower income groups (Social Exclusion Unit, 2003; Preston and Rajé, 2007).

We also consider the importance of differences between the incumbent population (i.e. people who had moved in before the subway line was constructed) and newcomers (i.e. people who moved in after the subway line was built). There are nine sets of statistically significant differences within both of the 14 specific sets of capabilities and functionings (last column of Table 3). It is found that most incumbent residents who lived in the subway station catchment areas before the subway lines were built are more likely to reap benefits than newcomers, in terms of both capabilities and functionings. This can be explained by the fact that most of the

incumbent population are local urban residents, whereas newcomers are more likely to be migrant workers who are renting properties. This reflects trends that we might envisage – most migrant workers are more likely to have lower wages than local urban residents, and are restricted to purchasing properties for which it is not necessary to hold a Beijing hukou. This is, however, quite different to findings in other contexts, where incomers constitute the wealthier groups. For example, this was found with the analysis of the Jubilee Line extension in East London, whereby wealthy incomers tended to use the system more and gain greater benefits than lower-income incumbent residents (Jones, 2015).

Table 3. Summary Test Statistics (F tests) for Differences in Individual Transport-related Social Justice by Gender, Income, and Incumbent Population in East Beijing (n=2,127)

Capabilities and Functionings	Gender	Household Income	Incumbent Population
Life			
C_travel safety (accidents)	1.268	8.371***	23.025***
F_travel safety (accidents)	0.983	2.199*	2.215
C_access grocery/clothes shopping	5.148*	22.275***	3.647
F_access grocery/clothes shopping	7.138**	2.497*	6.198*
Bodily Health			
C_access hospitals	3.900*	22.772***	4.920*
F_access hospitals	6.081*	5.430***	16.050***
C_active travel	0.312	8.811***	39.247***
F_active travel	0.814	6.374***	6.455*
Bodily Integrity			
C_travel safety (violent assault)	3.150	6.435***	43.351***
F_travel safety (violent assault)	2.841	3.730***	13.389***
Senses, Imagination, and Thought			
C_access training and education	15.778***	4.232***	3.899*
F_access training and education	11.702***	1.377	9.352**
C_creativity and imagination	10.335***	8.991***	5.438*
F_creativity and imagination	2.438	4.634***	0.002
Emotions			
C_travel and visit family/friends	4.951*	25.693***	6.215*
F_travel and visit family/friends	8.166**	14.521***	13.871***
Practical Reason			
C_access cultural activities	54.807***	9.973***	5.454*
F_access cultural activities	39.774***	4.900***	16.949***
Affiliation			
C_respect and get help	9.625**	9.965***	13.110***
F_respect and get help	13.467***	8.099***	0.048
Other Species			
C_against environmental degradation	1.649	9.212***	40.835***
F_against environmental degradation	5.022*	5.409***	16.812***
Play			
C_leisure and recreation	7.018**	17.840***	1.929
F_leisure and recreation	8.656**	1.571	2.151

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C_seek work opportunities	0.200	12.723***	17.338***
F_seek work opportunities	0.313	4.780***	12.274***
C_travel affordability	0.688	6.485***	60.697***
F_travel affordability	6.370*	8.692***	6.662**

Note: *p<0.05, **p<0.01, ***p<0.001.

4.2 Differences by Neighbourhood

The second hypothesis is that capabilities and functionings differ spatially by neighbourhood, i.e. different neighbourhoods within subway station catchment areas. Table 4 gives the results of MLR, showing how capabilities and functionings differ spatially between the different neighbourhoods of Guomao, Sihui and Tuqiao; keeping in mind that these three neighbourhoods have very different income profiles.

First, it is evident that Guomao, the central business area (CBD), has a much higher concentration of better-off urban hukou residents with higher levels of education and income than the other two areas. Most young and single white- or gold-collar workers (including foreigners) aged between 25 and 44 are concentrated in this area. In terms of travel behaviours, Guomao's residents usually spend a relatively short time commuting via their main mode of transport. This implies that the inner urban area provides better work and residence conditions than the suburbs. This finding is also in line with Jiang and Levinson's (2016) and Hu et al.'s (2017) research findings that there are regional disparities in job accessibility and job opportunity density, ranging from higher levels in the central areas to lower levels in the suburbs of Beijing.

Compared with Sihui and Tuqiao, Guomao's residents have relatively high levels of capabilities and functionings on most indicators, with the exception of a negative rating on 'accessing cultural and leisure activities'. In Guomao, those with white- or gold-collar lifestyles possibly lack leisure time, even though recreational facilities are highly accessible in this area (e.g. Jianwai SOHO and Jinri art gallery). Guomao's residents have relatively low levels of functionings in the category of 'control over one's environment', including 'seeking work opportunities' and 'affording travel expenses'. The former is linked to the highly competitive job market in Guomao, as most residents are more likely to be well-educated (the percentage who have a first degree or above is 71.9% in Guomao relative to 42.2% in Tuqiao), professional (e.g. many large, international business organisations are based in Guomao), and employed (employment rates are 95.1% in Guomao relative to 77.6% in Tuqiao). The latter results from the high cost of travel in Guomao. Only 11.3 per cent of Guomao's residents work in the same area that they live in, and their functioning therefore mismatches their capability with regard to travel affordability.

Second, it is appropriate to characterise Sihui's residents as more likely to be single non-urban hukou migrants. The rapid regional development of Sihui can be seen as a consequence of the spillover effects from the CBD area of Guomao. With its geographical proximity to Guomao, Sihui attracts more middle-income newcomers. Although more of Sihui's residents hold driving licences than their counterparts in Tuqiao and Guomao, they still tend not to travel by car due

to the availability of efficient and convenient public transport in the area.

The results of the model indicate that several functionings factors, such as 'active travel'; 'creativity and imagination'; 'respect and get help'; and 'travel safety (violent assault)', differed significantly from their corresponding capabilities factors, particularly when Sihui was compared with Guomao, as theOR computed as an exponent of values changed from a positive (or negative) to a negative (or positive) coefficient of estimates. For instance, in terms of travel safety (violent assault), which comes under the category of 'bodily integrity', the corresponding OR of functionings for the same category is 1.341, indicating that Sihui's residents generally felt safer and were less likely to suffer violent assault than Guomao's residents when travelling around the local area. However, the corresponding OR of capabilities for the same category is 0.581, which means the value of the estimate is opposite to that of the one for the functionings of travel safety. Mismatches between functionings and capabilities may be explained by Sihui's residents having relatively lower levels of actual travel and income.

Finally, Tuqiao's residents are more likely to be characterised as having lower socio-economic status than Sihui and Guomao's residents. The results reflect that a large number of Tuqiao's residents have lower education and income levels, and rent properties rather than owning them. Approximately 57.7 per cent of residents in Tuqiao do not have a first degree while the corresponding figures are only 31.5 per cent for Sihui and 28.1 per cent for Guomao. Not surprisingly, the income levels of people in Tuqiao over the past 12 months are much lower than those in Sihui and particularly Guomao.

It was found that there were no statistically significant differences in income levels in the years 1999/2003, before the subway stations were built in the corresponding areas. Therefore, this implies that the proportional income level of Tuqiao's residents has not improved compared with that of their counterparts in Sihui and Guomao. Although scholars have suggested that large scale investment in transport infrastructure can increase employment, economic development, and commercial and residential property values in the station catchment areas (Banister and Berechman, 2000; Banister and Thurstain-Goodwin, 2011; Pan et al., 2014; Jones, 2015), the analysis for Beijing shows that public transport infrastructure investment mostly benefits middle- and higher-income groups rather than lower-income cohorts, particularly in terms of their access to activities.

Table 4. Model Estimated Parameters of Transport and Social Equity with Spatial Difference (MLR Results[f])

Variables	Sihui vs. Tuqiao[a]			Guomao vs. Tuqiao			Sihui vs. Guomao[b]		
	B	SE[c]	OR[d]	B	SE	OR	B	SE	OR
(Intercept)	-3.897***	0.815	\	-11.788***	1.018	\	7.406***	0.940	\
Demographics									
Gender	.424**	0.150	1.528	0.202	0.160	1.224	0.222	0.139	1.248
Education	1.111***	0.175	3.038	1.066***	0.189	2.905	0.045	0.175	1.046
Age	-0.109	0.089	0.897	-0.015	0.097	0.985	-0.094	0.090	0.910
Housing tenure	.464*	0.197	1.591	.649**	0.223	1.914	-0.185	0.189	0.831
Marital status	-.927***	0.187	0.396	-.753***	0.204	0.471	-0.174	0.173	0.840
Hukou status									
Urban *hukou*	-.662**	0.213	0.516	1.523***	0.329	4.585	-2.185***	0.299	0.112
Local urban *hukou*	0.051	0.206	1.053	-0.168	0.231	0.846	0.219	0.185	1.245
Incumbent population	-.869***	0.183	0.419	-0.237	0.205	0.789	-.632***	0.167	0.531
Socio-economics									
Employment	-0.084	0.304	0.919	0.287	0.374	1.333	-0.371	0.335	0.690
Driving licence	.438*	0.209	1.550	0.013	0.235	1.013	.425*	0.206	1.530
Car ownership	.510*	0.212	1.666	0.276	0.228	1.318	0.234	0.207	1.264
Travel time									
Main transport mode for work	-.010**	0.003	0.990	-.010**	0.004	0.990	0.000	0.004	1.000
Main transport mode for non-work activities	0.003	0.002	1.003	.012***	0.003	1.012	-.010***	0.002	0.991
Monthly household income (RMB)									
In the year 1999/2003	0.070	0.072	1.073	-0.128	0.081	0.880	.198**	0.064	1.218
During the past 12 months	.168*	0.078	1.183	.510***	0.088	1.665	-.341***	0.075	0.711
Functionings									

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	B	SE	Exp(B)	B	SE	Exp(B)	B	SE	Exp(B)
Life									
F_travel safety (accidents)	-.449***	0.120	0.638	-.535***	0.139	0.586	0.085	0.113	1.089
F_access grocery/clothes shopping	-.379**	0.124	0.685	-.393**	0.141	0.675	0.015	0.114	1.015
Bodily Health									
F_access hospitals	0.159	0.106	1.172	0.115	0.119	1.122	0.044	0.105	1.045
F_active travel	.320***	0.092	1.377	0.082	0.102	1.086	.237**	0.088	1.268
Bodily Integrity									
F_travel safety (violent assault)	0.211	0.115	1.235	-0.083	0.135	0.921	.294**	0.113	1.341
Senses, Imagination, and Thought									
F_access training and education	0.122	0.113	1.130	-0.068	0.125	0.934	0.190	0.114	1.210
F_creativity and imagination	-.412***	0.095	0.662	0.088	0.111	1.092	-.500***	0.094	0.606
Emotions									
F_travel and visit family/friends	-0.114	0.115	0.893	0.154	0.129	1.166	-.267*	0.111	0.766
Practical Reason									
F_access cultural activities	0.172	0.117	1.188	0.032	0.126	1.033	0.140	0.112	1.150
Affiliation									
F_respect and get help	.278**	0.106	1.320	-0.155	0.125	0.856	.433***	0.104	1.542
Other Species									
F_against environmental degradation	-0.109	0.100	0.897	-.236*	0.115	0.790	0.127	0.096	1.136
Play									
F_leisure and recreation	.229*	0.111	1.257	.529***	0.123	1.698	-.300**	0.105	0.741
Control Over One's Environment									
F_seek work opportunities	-0.057	0.113	0.944	-.323**	0.122	0.724	.266*	0.110	1.305
F_travel affordability	0.200	0.130	1.221	-.378*	0.154	0.685	.578***	0.135	1.782
F_political participation									

Capabilities

Life

C_travel safety (accidents)	-0.072	0.107	0.930	0.237	0.124	1.268	-.310**	0.103	0.734
C_access grocery/clothes shopping	.326*	0.164	1.385	.517**	0.185	1.677	-0.191	0.158	0.826

Bodily Health

C_access hospitals	-0.030	0.151	0.970	0.061	0.165	1.063	-0.092	0.138	0.912
C_active travel	.327***	0.081	1.387	.561***	0.094	1.753	-.234**	0.080	0.791

Bodily Integrity

C_travel safety (violent assault)	-.610***	0.112	0.543	-0.067	0.128	0.935	-.543***	0.109	0.581

Senses, Imagination, and Thought

C_access training and education	-0.051	0.105	0.950	.294*	0.120	1.342	-.345***	0.106	0.708
C_creativity and imagination	.506***	0.098	1.658	-0.082	0.114	0.922	.588***	0.096	1.800

Emotions

C_travel and visit family/friends	0.113	0.141	1.119	0.243	0.163	1.275	-0.131	0.138	0.878

Practical Reason

C_access cultural activities	-.469***	0.118	0.626	-.782***	0.126	0.457	.313**	0.106	1.368

Affiliation

C_respect and get help	0.014	0.102	1.014	.448***	0.118	1.565	-.433***	0.100	0.648

Other Species

C_against environmental degradation	-0.064	0.096	0.938	0.196	0.111	1.217	-.261**	0.095	0.770

Play

C_leisure and recreation	.289*	0.136	1.335	-.302*	0.144	0.739	.591***	0.134	1.805

Control Over One's Environment

C_seek work opportunities	0.186	0.113	1.204	0.184	0.120	1.202	0.002	0.111	1.002
C_travel affordability	-.270*	0.109	0.764	.347**	0.133	1.415	-.617***	0.116	0.540

Model Statistics

n	2,127[e]
χ2	2045.485
Significance	p < 0.001
-2 × Log Likelihood	3064.680
Pseudo R-Square	
Cox and Snell	0.583
Nagelkerke	0.657
Note:	* p < 0.05; **p < 0.01; ***p < 0.001.
	a: Dependent variable is area, 'Tuqiao' is selected as reference category.
	b: Dependent variable is area, 'Guomao' is selected as reference category.
	c: SE = Standard Error.
	d: OR = Odds Ratio.
	e: 'Not applicable' responses in the survey research are treated as missing values in statistical terms. Therefore, the sample sizes used in the analysis are 2,127.
	f: MLR results of the other three models are not shown (model 1 only considers demographic variables; model 2 controls for socio-economic variables while considering the model as a whole; model 3 controls for functionings while considering the model as a whole).

5. Conclusions

This paper has explored the implications of transport-related social equity for individuals, depending on their socio-economic characteristics and neighbourhood location, focusing on residents who live in the three subway station catchment areas in East Beijing, and using the CA as a theoretical framework. The approach adapted from Nussbaum's (2003) central human capabilities theory gives a wide-ranging, multidimensional perspective to the analysis of social impacts and enables the subjectivities associated with travel and participation in activities to be quantified to some extent. Alongside this, it is important that there is a strong qualitative understanding of the impacts, perhaps via interviews, otherwise many of the nuances in the activities are likely to be lost.

The analysis shows that there are significant differences between capabilities, functionings, and the gap between them across socio-economic characteristics and different neighbourhoods. First, this study found that females generally had higher levels of both capabilities and functionings, compared to males, for some key indicators, such as accessing grocery and clothes shopping; gaining respect and help; travelling and visiting family and friends; training and education; cultural activities; and leisure and recreation. However, there are no statistically significant differences for access to employment, at least in this data. These findings can add to the existing studies exploring transport-related gender difference (Næss, 2008; Uteng and Cresswell, 2008). Efforts have made by the Chinese Communist government to challenge a strong, inequitable gender-related hierarchy both within and outside the family in traditional Chinese society. In earlier years, females were generally heavily subordinate to males and occupied the lower strata of the hierarchy (Bauer et al., 1992), and this research suggests that some gains might be evident. There, of course, remain many areas to develop in encouraging more equitable participation, including spatial variations, and tackling the precarity of part time and temporary work.

In addition, we also provides new evidence arguing that the incumbent population are likely to gain greater benefits than newcomers. This is different to previous empirical studies conducted in a Western context, such as the case of the Jubilee Line extension in London (Lane et al., 2004; Jones, 2015), and reflects the hukou and migrant movement into cities. Finally, three patterns of neighbourhoods characterised by different types of income groups and developments, namely Tuqiao; Sihui; and Guomao, were identified. This research found that Tuqiao, where most of the lower-income people live, scores lower on the indicators, mainly because residents' income levels have not improved compared with their counterparts in Sihui and Guomao. In other words, Tuqiao's residents may gain fewer benefits from the local transport infrastructure than people living in Sihui and Guomao, even though, for example, they all live very similar distances from the local subway stations. Therefore, based on the findings, we suggest that socio-spatial issues related to transport inequity also need to be taken into account in transport and urban planning and should be used by policy makers to inform transport policies (e.g. Beijing Municipal Commission of Transport) (Zhao and Li, 2016). There can be further analysis on levels of transport-related social inequity and policy measures

developed to help address this. Improving accessibility to public transport services, improved public transport networks and walking and cycling facilities are important first steps in reducing inequities, but also there need to be attempts to reduce the barriers to using this improved infrastructure and accessibility. These can be varied and complex, including improving income and skill levels, employment availability and the existence of the hukou system.

We argue that understanding an individual's capabilities and functionings may further help to improve accessibility planning – giving a focus on real opportunities and actual activities – which can help explain why people with similar accessibility levels often experience differing travel and activity participation. However, the capabilities concept (representing real opportunities) is difficult to apply empirically and needs further research and discussion. There are limitations to our research. For example, the concept of capabilities is difficult to understand and may not lend itself to being measured by surveys. It is therefore suggested that more in-depth interviews could be used to supplement survey results and help to understand the real opportunities available to people, moving beyond the individual perception of desire. In addition, a focus on CA also tells us little about procedural equity, and this is an important element of social equity.

This paper contributes to the existing literature regarding transport-related social equity in the following ways. Firstly, most of the prior transport studies tend to put forward accessibility as the key indicator with which to measure equity in a transport context. We concur that this is a useful progression from the conventional focus on mobility metrics and that there is a much greater need for mobility justice across population groups (Bocarejo and Oviedo, 2012; Geurs and Van Wee, 2004; Lucas, 2012; Martens, 2012; Martens and Di Ciommo, 2017; Social Exclusion Unit, 2003; Sheller, 2019). But, also, analysis within accessibility planning often overlooks some of the underlying reasons for travel and the barriers to access. These include structural constraints, such as the political and cultural context to travel in different jurisdictions. Participation in activities varies enormously between individuals, and perhaps we do not understand this process well enough to provide a basis for policy interventions that might lead to a greater level of travel equity. Of course, there are wider policy goals beyond social equity, including environmental and well-being objectives, and these also need to be considered. Critically, economic growth becomes a means to achieve social and environmental objectives, and not only an end in itself. In practice, there is a need for a more comprehensive framework that allows transport projects to be judged against multiple and competing goals.

Ultimately, it is necessary to consider and try to improve what an individual and society is able to do and to be (Sen, 1999), including through investment in an appropriate transport system. The policy document 'Building a Harmonious Society' (BHS) (People.cn, 2006; Chan, 2009) provides a vision for China's future development, introduced by the former Chinese President Hu in 2004. One of the six key roles of the BHS is to ensure 'justice and equality'. Since Confucius' time, social equity has been an important objective in China – but this has been overlooked with the recent focus on economic growth. We hope this paper contributes to a strengthened debate on the role of transport in supporting fairer access to opportunities, livelihood, education and resources.

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