Does Satisfactory Neighbourhood Environment Lead to a Satisfying Life? An Investigation of the Association between Neighbourhood Environment and Life Satisfaction in Beijing

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Abstract:

Associated with the dramatic expansion of Chinese cities are the unprecedented scale and pace of changes to urban living environment. There is an imperative to assess residents' perceptions of neighbourhood environment and the impacts on life satisfaction. Drawing on a large-scale residential satisfaction survey conducted in Beijing in 2013, we examine the fine-grained spatial distribution and determinants of residents' life satisfaction. A multilevel ordinal response model is employed to investigate the roles of neighbourhood satisfaction, perceived relative income, socio-demographic characteristics, and contextual factors in predicting life satisfaction. Results show that satisfaction with key neighbourhood characteristics including safety, physical and social environments, and travel convenience is statistically significantly associated with life satisfaction. Income relative to that of peers in local areas or to that in the past is a more important predictor of life satisfaction than absolute income. Other individual-level variables, such as age, family structure, *hukou* status, health, commuting time, and housing-related variables including housing tenure and floor space, are significant correlates of life satisfaction.

1. Introduction

In the past three decades China has witnessed remarkable economic growth and dramatic urban expansion and regeneration, resulting in massive changes to both the macro-scale landscapes and micro-scale neighbourhood environment in cities (Chen & Chen, 2015). In contrast with the economic prosperity and improved living conditions is a steady decline of life satisfaction among the general population (Li & Raine, 2014). This reflects the Easterline Paradox which refutes the positive relationship between economic growth and life satisfaction (Easterlin et al., 2012). The declining trend of life satisfaction is likely to be exacerbated by the documented steady increase of income inequality in China (Xie & Zhou, 2014), which has been identified as a potential predictor of life satisfaction (Dolan et al., 2008).

This raises an important question about the key determinants of life satisfaction, defined as the cognitive assessment of one's life conditions based on the comparison between aspirations and achievements (Fernandez-Portero et al., 2017). As life satisfaction is an essential component of subjective wellbeing, a better understanding of its determinants can help inform policies aimed at enhancing human welfare (Diener et al., 2012). Neighbourhood environment is an important domain relevant to life satisfaction, as people spend a large proportion of time in neighbourhoods for physical activities and social interaction. With massive neighbourhood changes in Chinese cities over recent years, there is an imperative to explore residents' perception or assessment of their neighbourhood environment, as well as its impacts on life satisfaction. Whilst the socio-demographic, economic and institutional correlates of life satisfaction at the city scale have been discussed extensively in China (e.g.

Appleton & Song, 2008; Bian et al., 2015; Li & Wu, 2013), relatively few studies focus on the physical and social aspects of residential environment at the district or neighbourhood scale (e.g. Liu et al., 2017; Dong & Qin, 2017). Even fewer studies examine the fine-grained spatial variations of life satisfaction in a Chinese megacity, and the role of subjective evaluation on the multiple facets of neighbourhood environment and income inequality.

This paper aims to extend the literature by exploring the socio-spatial variations of life satisfaction in urban Beijing and developing a broad conceptual framework to examine its determinants. Drawing upon a large-scale residential satisfaction survey conducted in Beijing in 2013, we for the first time present the geographical distributions of residential environment evaluation and life satisfaction at the sub-district or *jiedao* level. We then investigate the impacts on life satisfaction of both objective and subjective measures, including socio-demographics, economic attributes, health status, commuting time, locational and contextual variables, and most importantly, the subjective evaluation of neighbourhood environment and perceived relative income. In particular, we address the following research questions: whether and to what extent satisfaction with a variety of neighbourhood characteristics and perceived relative income are associated with life satisfaction; and how these subjective measures mediate the relationship between life satisfaction and objective residential environment and absolute income.

The paper contributes to the literature in three aspects. First, existing studies on residential environment and life satisfaction focus on the roles of objective neighbourhood characteristics, such as accessibility to urban amenities and public transport. The mediating role of the subjective evaluation of these characteristics is largely ignored. Perceived neighbourhood environment might have a direct and possibly larger effect on life satisfaction than objective measures, and it might mediate the effect of built environment on life satisfaction. We examine the impacts on life satisfaction of both objective residential

environment and subjective evaluations of four core neighbourhood environment: safety, physical environment, social environment and travel convenience. Second, we extend the debate on Easterlin paradox by incorporating perceived relative income into the life satisfaction research. Relative income has been found to be significantly associated with subjective wellbeing in Western literature, and is proposed to explain the Easterlin paradox. However, it has been argued that individuals only respond to their perceived inequality rather than the factual one (Scheneider, 2016). We explicitly examine the roles of perceived relative income in the Chinese context, and investigate how it might mediate the relationship between absolute income and life satisfaction. Last but not the least, as life satisfaction may be influenced by residential environment at different geographical scales, we employ a rigorous multilevel ordinal response model to capture the unobserved influences of geographical contexts upon individuals, as well as the ordinal nature of self-rated life satisfaction responses and the hierarchical structure of our survey data. Overall, this paper presents a solid empirical study with rigorous statistical analyses under a comprehensively theoretical framework, and makes a timely contribution to better understanding of life satisfaction in urban China.

The rest of the paper is structured as follows. We begin with a brief review of previous studies on life satisfaction, and then present our theoretical framework. This is followed by the discussions of the data, model specification, and results of multilevel models. We conclude the paper with a summary of key findings and policy implications.

2. Literature review

As life satisfaction is an important indicator of human welfare, both theoretical and empirical studies have been conducted to understand its concept and determinants. The need satisfaction theory maintains that satisfaction with life is contingent on the extent to which

individuals' needs are fulfilled (Diener et al., 2012). According to the need hierarchy theory (Maslow, 1970), people have different kinds of needs (e.g. decent housing, adequate living materials, safety, social interaction), and individuals may feel satisfied with life when their needs are met. The goal satisfaction theory states that individuals set their goals, and express satisfaction with life when they achieve the goals or make good progress towards them (Omodei & Wearing, 1990). The need or goal theory is extended by the multiple discrepancy theory (Michalos, 1985) which introduces the perspective of social comparison. It argues that life satisfaction is 'inversely related to the degree of discrepancy from multiple standards, including what one wants, what one has had in the past, and what relevant others have' (Diener et al., 2012, p.66). If individuals' current circumstances are inferior to their reference group or their own past, they may express dissatisfaction with life. Thus, the concept is claimed to be vulnerable to adaptation, as social comparison and the choice of a reference group matter.

Life satisfaction is an overall evaluation of different dimensions of life, including residential environment, jobs, health and family. Residential environment is an important dimension because it 'can efficiently capture localised forces that affect people's lives and provide a sense of place' (Bardhan et al., 2015, p.57). It is a multi-faceted concept, including physical surroundings, such as location and access to services and amenities, as well as social milieus, such as crime and social interaction (Swaroop & Krysan, 2011). Campbell's model (1976) provides a theoretical framework which explains the mechanism connecting residential (built) environment and life satisfaction. Residential environment represents an important source of need satisfaction, including safety, esteem and social support. According to the model, objective residential characteristics act as stimuli which influence individuals' perception of surrounding environment. Such cognitive assessments influence residential satisfaction which affects overall life satisfaction. One implication from Campbell's model is

that residential environment may influence life satisfaction indirectly through individuals' perception and evaluation of such environment.

With or without a theoretical framework, a variety of empirical studies have been conducted to examine the role of place, space and built environment in influencing life satisfaction (Ballas, 2013). Many of these studies focus on the city scale. For example, using a two-level logistic regression model, Weziak-Bialowolska (2016) examine the impact on quality of life of personal characteristics and urban contexts across 79 European cities. The results show that contextual factors, such as the financial conditions and safety environment significantly influence people's life satisfaction. Drawing on data from the World Values Survey, Berry and Okulicz-Kozaryn (2009) suggest that city size has no significant effect on subjective wellbeing at the global level, whereas in higher income countries, life dissatisfaction increases with the size of the city.

Recent years have seen a growing number of empirical studies on the impacts of neighbourhood environment on life satisfaction. Morrison (2011) reported a positive relationship between access to shops, services and amenities and residents' subjective evaluation of life conditions. Ambrey and Fleming (2014) find that access to green space contributes to life satisfaction in Australian cities. Shields et al (2009) conclude that neighbourhood measures of social interaction and the absence of socio-economic deprivation are positively and significantly correlated with residents' life satisfaction. In addition to objective residential characteristics, individuals' subjective evaluations of neighbourhood environment have also been demonstrated to influence life satisfaction (Ibem & Amole, 2013). For example, Phillips et al (2005) examine the role of residential satisfaction in mediating the effects of housing conditions on psychological wellbeing for older people in Hong Kong. They conclude that objective housing conditions have no direct impact on subjective wellbeing, however, they affect wellbeing indirectly through residential

satisfaction. Using data from the Minneapolis-St. Paul metropolitan area, Cao (2016) applies structural equation models to estimate the direct and indirect effects on life satisfaction of objective neighbourhood characteristics and subjective residential satisfaction, and reports significant correlations between neighbourhood design, especially population density and street connectivity, and subjective wellbeing. These researchers tend to argue that the subjective evaluation of environment or neighbourhood satisfaction exerts greater effects on life satisfaction, and it might mediate the relationship between objective environment and overall life satisfaction.

Besides residential environment, a wide range of factors have been shown to influence life satisfaction, such as demographic and socio-economic characteristics, employment status, housing conditions and health, as these factors influence individuals' needs and aspirations of life. For example, age is demonstrated to be correlated with life satisfaction, with middle-aged people more likely to express a lower level of life satisfaction compared with the young and the elderly, due to family and other responsibilities (Blanchflower & Oswald, 2004). Economic factors, such as price level and employment, are found to be correlated with life satisfaction, as people are more likely to be satisfied with life when inflation or unemployment rate is low (Dolan et al., 2008). Income represents an area of particular interest (see Clark et al. (2008) for a review). Some studies show a positive correlation between income and subjective wellbeing (SWB), as people with more economic resources might have a greater ability to fulfill their needs (Blanchflower & Oswald, 2004). However, using time-series data in various industrialised countries, Easterlin (2001) finds that income growth does not necessarily lead to an increase in life satisfaction and puts forward 'the Easterlin paradox'. One explanation concerns the relative income hypothesis or the social comparison hypothesis which indicates that people tend to rate their satisfaction levels after comparing their current income with that in the past or that of others,

corresponding to the multiple discrepancy theory (Wilkinson & Pickett, 2009). Relative income is reported to exert a larger effect on life satisfaction than absolute income (Clark et al., 2008; Huang et al., 2016).

Most prior research on China focuses on the impacts on life satisfaction of individual socio-economic attributes, economic development and geographical variations at the regional or city level (e.g. Liu et al., 2015; Wu & Tam, 2015). For instance, Chen et al (2015) find that health status, income, city size, and pathways to urban residency are significantly associated with life satisfaction in urban China. Bian et al (2015) report that health, social support and integration are important predictors of subjective wellbeing in less developed western regions of China. However, there are relatively few studies which link urban form and life satisfaction at a fine spatial scale in China (Wang & Wang, 2016). More recently, Liu et al (2017) investigate the impacts of residential environment and social support on migrants' subjective wellbeing in Guangzhou, and suggest that social environment and social support are significantly correlated with migrants' life satisfaction, whereas neighbourhood physical environment, such as cleanliness and amenities, show no significant effects. In contrast, using data from 16 surveyed neighbourhoods in Beijing, Dong and Qin (2017) conclude that neighbourhood environment exerts a significant but minor impact on subjective wellbeing; they identify the most valued neighbourhood attributes as safety, residential convenience and transit accessibility.

To conclude, it is evident that research findings on life satisfaction are equivocal. Whilst most prior research has focused on either objective or subjective measures, relatively few empirical attempts have been made to combine the two approaches together (Ballas, 2013). Guided by the theories on life satisfaction and previous studies, we develop a comprehensively analytical framework to examine the determinants of life satisfaction, including both objective and subjective measures, as shown in Figure 1. In addition to the

roles of socio-demographics, economic attributes and health status which have been widely tested in previous studies, we include the effects of neighbourhood satisfaction, perceived relative income, commuting time, and multi-scale objective residential environment. Campbell's model indicates that objective environmental attributes may influence life satisfaction through the mediating effect of residential satisfaction which is an important source of overall life satisfaction. The multiple discrepancy theory highlights the important roles of social comparison and relative income. As individuals tend to respond to their perceived inequality, perceived relative income is included in the framework. Commuting time is found to exert significant impacts on life satisfaction in developed countries (Dolan et al., 2008), but rarely tested in the Chinese context. With rapid urban expansion in recent years, commuting may influence many people's life in Chinese mega-cities. Specifically, we hypothesise that:

1) Neighbourhood satisfaction significantly improves individuals' overall evaluation of life, and it mediates the relationship between objective residential environment and life satisfaction.

2) Perceived relative income significantly influences life satisfaction, and it mediates the effect of absolute income on life satisfaction.

3) Socio-demographic attributes (e.g. gender, age, marital status) and economic status (e.g. income, housing tenure, housing area), commuting time and health conditions are significant correlates of life satisfaction.

[Figure 1 about here]

3. Methodology

3.1. Data

Our analyses are drawn on a large-scale residential satisfaction survey conducted in urban Beijing in 2013. The survey aims to investigate residents' satisfaction with living environment and their overall life satisfaction. It targets residents who had lived in their residences for over six months at the time of the survey. A stratified random sampling strategy was adopted, with about 0.1% of the population in each of the six districts sampled across urban Beijing. In total, 7,000 questionnaires were issued with about 6,000 returned, of which 5,010 have valid information on the variables used in this study. The survey data are reported to be representative of Beijing's residents, compared to the 2010 population census (Zhang et al., 2015). Based on residential information, a two-level membership structure is formed by assigning individuals to sub-districts (*Jiedao*). A sub-district is the basic administrative unit in a Chinese city and the finest spatial unit at which census variables and geographic boundaries are publicly available. Residential characteristics at the sub-district level may influence individuals' life satisfaction because public service provision and residents' socio-economic composition are different across sub-districts. The study area and the spatial distribution of the respondents are illustrated in Fig. 2.

[Figure 2 about here]

Table 1 displays summary statistics for the variables used in this study. Self-rated life satisfaction is the outcome variable measured by the survey question: 'All things considered, how satisfied are you with your life as a whole?'. Responses are quantified on a 5-point Likert scale ranging from 1 (*very unsatisfied*) to 5 (*very satisfied*). As shown in Table 1, more than 50% of the respondents were satisfied with their lives, followed by those who rated life satisfaction as 'fair'; only small proportions of respondents reported 'very unsatisfied' (0.56%) or 'very satisfied' (6.39%). Fig. 3 presents the spatial distribution of life satisfaction

aggregated at the sub-district scale, with breaking points being the lower quantile, median and upper quantile of the variable. The spatial variation of life satisfaction is evident across urban Beijing, with sub-districts located in the inner city and in the northeast having higher average scores of life satisfaction, although the spatial pattern seems to be fragmented.

[Table 1 about here]

[Figure 3 about here]

Neighbourhood satisfaction in this research focuses on four key dimensions: neighbourhood safety including social security, traffic safety and the provision of emergency shelters; physical environment such as green area and open space nearby; social environment including social interaction and neighbourhood attachment; and travel convenience, such as access to transport hubs and shopping centres. Respondents were asked to rate their satisfaction levels with each of the four neighbourhood dimensions on a five-point Likert scale with one being 'very unsatisfied' and five 'very satisfied'. Fig. 4 presents the spatial distributions of satisfaction with four neighbourhood domains, with breaking points being the lower, median and upper quantiles of the corresponding variables. It shows heterogeneous spatial patterns of domain-specific neighbourhood satisfaction, with the sub-districts located on the city fringe faring relatively poorly than those in the inner city, especially in terms of social environment and travel convenience.

[Figure 4 about here]

To test the relative income hypothesis, two perceived relative income variables are used in our life satisfaction equation. They are derived from two survey questions: 'all things

considered, how satisfied you are with your current income compared to that of peers in the neighbouring areas and to your own past income'. Responses are quantified on a 5-point Likert scale ranging from 1 (very unsatisfied) to 5 (very satisfied). These variables allow us to test the mediating effect of relative income on the association between life satisfaction and absolute income. We acknowledge that an individual's reference group is socially defined, and the perceived relative income is likely to be based on the individual's social networks such as friends, relatives or colleagues at a broader geographical context than neighbouring areas. However, individuals do spend a large amount of time in their neighbouring areas cultivating social ties and networks. In the survey, respondents were allowed to make their own definitions of 'peers' and 'neighbouring areas'. Therefore, the reference group is relevant to respondents and the variable is valuable in measuring perceived relative income.

Other independent variables are broadly divided into the following categories. The first includes socio-demographic attributes, such as age, gender, marital status, household with children under six[1], education, income[2], residential status (local residents vs. migrants) and employment. Second, housing characteristics, such as housing tenure, floor space and housing type (i.e. work-unit or *Danwei*, commodity, affordable, and self-built) are included in the analysis, due to their high relevance to subjective wellbeing (Ma et al., 2017). The possible impact on life satisfaction of residential duration is captured via two variables: residential mobility (whether the respondent had moved home since 2009) and the duration in the current residence (if not moved since 2009). Self-rated health and commuting time are also taken into account in the analysis. Moreover, a set of locational factors, measuring the micro-scale neighbourhood amenities, such as the distances to public transit, green space, and

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[1] Children under six may require a large amount of parental care before they go to school at seven.

[2] Income is originally recorded as a categorical variable with seven income bands, but has been converted to a continuous variable using the midpoints of each income band with value for the open-ended top category extrapolated following Ferreira and Moro (2013). The same procedure is applied to the age variable.

the city centre, are included in the model. Finally, some socio-demographic characteristics at sub-district level, including the proportions of migrants, homeowners and buildings built after year 2000, are incorporated in the analysis. These variables are derived from the 2010 population census and used to measure the contextual effects at a broad geographic scale. They reflect residents' socio-economic composition and recent urban development which might influence quality of life (Shields et al., 2009).

3.2. Statistical model

Due to the two-level structure of our survey data (individuals nested into sub-districts) and the ordinal nature of the outcome variable of life satisfaction, a multilevel ordinal response model is employed (Goldstein, 2003). Let $y_{ik,j}$ represent the life satisfaction score of individual i living in sub-district k. The cumulative probability of the score falling in the jth category or below $P(y_{ik,j} \leq j)$ is related to a range of predictor variables via a logit link function,

$$\log \frac{P(y_{ik,j} \leq j)}{1 - P(y_{ik,j} \leq j)} = \alpha_j - X'_{ik}\boldsymbol{\beta} - Z'_k\boldsymbol{\gamma} - u_k \qquad (1)$$

where a_j (j = 1, 2,…, J-1) is the threshold parameter associated with the cumulative distribution of the jth response category. X and Z represent individual- and sub-district level predictors while vectors of $\boldsymbol{\beta}$ and $\boldsymbol{\gamma}$ are regression coefficients to estimate. The vector u captures the unobservable sub-district level effect, following a normal distribution $N(0, \sigma_u^2)$. The importance of the unobservable effect is quantified by using the variance partitioning coefficient ($\sigma_u^2/(\sigma_u^2 + \pi^2/3)$) (Goldstein et al., 2002). To facilitate the interpretation and comparability of regression coefficients, all of the continuous variables are first mean centred, and then scaled by dividing by twice their standard deviations (Gelman, 2008).

The multilevel ordinal response model is estimated using a Bayesian approach, because a frequentist approach such as the maximum likelihood estimation is highly unstable

especially for the variance parameters. Equation (1) accompanied with the prior distributions for each unknown model parameter completes the model specification. Following Gelman et al (2014), improper flat prior distributions are employed for regression coefficients with an inverse Gamma distribution for σ_u^2. Equation (1) is implemented by using the R *brms* package (Bürkner in press), which fits a range of Bayesian multilevel models in R with the probabilistic programming language Stan as the backbone of the estimation process (Hoffman & Gelman, 2014). The statistical inferences of the parameters in the models fitted in this study are based on three chains, each with 10,000 iterations, of which the first 5,000 are warmup to calibrate the Stan sampler.

4. Results

Four models with increasing complexity are sequentially estimated. The baseline model (Model 1) includes the individual socio-demographic attributes and housing-related variables. These variables are demonstrated to be correlates of life satisfaction in previous studies (e.g. Clark et al., 2008; Dolan et al., 2008). Locational and sub-district level characteristics are added in Model 2 to examine the impacts of objective contextual variables at different geographic scales on life satisfaction. To test the social comparison hypothesis, variables on perceived relative income are added in Model 3. Finally, a set of neighbourhood satisfaction variables are incorporated in Model 4. Model comparisons are performed by using the Watanabe-Akaike information criterion (WAIC, Watanabe, 2010). WAIC belongs to deviance-class model fit indices with smaller values indicating a better model fit. The difference in WAIC from two models applied to the same data follows a normal distribution, so the statistical significance of the difference in model fit can be inferred by dividing the difference in WAIC by its standard error (Watanabe, 2010).

Table 2 displays the estimation results of Model 1 and 2. By and large, the findings on the effects of socio-demographic attributes and housing-related variables in Model 1 are consistent with previous studies (e.g. Dolan et al., 2008). Age appears to have a non-linear association with life satisfaction: younger and older people tend to report higher levels of satisfaction than middle-aged adults, *ceteris paribus*. Household income is significantly and positively related with life satisfaction, which we will discuss in depth later. Differences in life satisfaction are observed between people with tertiary and secondary education levels, with the former more likely to express higher levels of life satisfaction. Marriage appears to increase life satisfaction while the presence of children under six decreases it. One explanation concerns the responsibilities and the large amount of care required for raising a child before he or she goes to school. With respect to residential status, migrants tend to report a significantly lower level of life satisfaction compared to local residents, holding everything else equal. The finding corresponds to previous studies which demonstrate migrants' low levels of subjective wellbeing (Liu et al., 2017). Compared with local residents, migrants are more likely to take low-paid jobs and live in poor-quality housing. The effects of gender and employment status on life satisfaction are found to be insignificant.

[Table 2 about here]

Regarding the housing-related predictors, homeowners tend to report a higher level of life satisfaction compared to renters. Residents living in commodity housing are associated with higher satisfaction levels than those residing in affordable housing, while the differences between living in affordable, work-unit and self-built housing are not statistically significant. There appears to be a significant effect of living space on life satisfaction: residents living in apartments with floor areas above 80m^2 are associated with an elevated satisfaction level compared with those living in small apartments (40m^2-80m^2). Residential length also matters:

residents living in the current residence for more than five years (not moved since 2009) tend to report a higher satisfaction level than their counterparts; for those who moved to the current residence after 2009, longer duration of residence is also associated with greater odds of reporting higher satisfaction levels. Commuting time, a measure of job-housing spatial mismatch, is negatively associated with life satisfaction, which echoes the findings in Stutzer and Frey (2008) using data from Germany.

Model 2 estimates the impacts on life satisfaction of locational variables and objective sub-district attributes while holding constant the socio-demographic and housing variables. Whilst closer proximity to railway stations improves life satisfaction, the distance to the nearest park is not significant, everything else being equal. Proximity to the city center is negatively associated with the odds of reporting higher satisfaction levels, *ceteris paribus*. The variance estimate in Model 2 shows that the sub-district level heterogeneity accounts for about four percent of the total variation in the latent life satisfaction scores, although they are statistically insignificant. We note that the coefficients of socio-demographic and housing-related predictors are similar in the two models, expect that the effect of employment status is flagged up as statistically significant in Model 2. In terms of model fit, the WAIC statistic is smaller in Model 2 than in Model 1. However, the difference is not statistically significant, as shown in the last row of Table 2, indicating the trivial role of these variables in explaining life satisfaction variations.

Before reporting the estimation results from Models 3 and 4, we ran a series of regression models to examine the associations between perceived relative income and absolute income, and the associations between subjective neighbourhood evaluation and objective sub-district characteristics. We find that perceived relative income is statistically significantly associated with absolute income, and that the satisfaction with each neighbourhood domain is significantly correlated to objective sub-district variables. These

findings provide solid grounds for our postulation that the subjective measures on relative income and neighbourhood satisfaction might act as mediators in the links between objective measures and life satisfaction.

Results of Model 3 and 4 are presented in Table 3. After the variables of perceived relative income and self-rated health are added to Model 3, there is a significant decrease in WAIC and thus a significant improvement in model fit from Model 2 (the bottom of Table 3), demonstrating the importance of these covariates. Coinciding with previous studies, self-rated health is significantly associated with life satisfaction: people with good health status are more likely to report higher levels of life satisfaction. Perceived relative income compared to peers in neighbouring areas is significantly associated with life satisfaction, and so is perceived relative income compared to previous income. It is important to note that, once perceived relative incomes are controlled for, the association between absolute income and life satisfaction is no longer statistically significant. This suggests that perceived relative income is a more important predictor of life satisfaction than absolute income, and that perceived relative income substantively mediates the relationship between absolute income and life satisfaction. Other variables that are significantly associated with life satisfaction in Model 2 but not so in Model 3 include educational achievement, residential length and proximity to the city centre.

[Table 3 about here]

A further inclusion of neighbourhood satisfaction variables in Model 4 leads to a significant improvement in model fit, compared to Model 3. Satisfaction with neighbourhood attributes, i.e. safety, physical environment, social environment and travel convenience, are all significantly and positively associated with life satisfaction, everything else being equal. Estimates on the coefficients of other variables in Model 4 remain similar to those in Model 3,

except for the percentage of buildings after 2000 at sub-district level which turns to be significant. One explanation is that sub-districts with a larger proportion of new buildings tend to offer high-quality housing and better residential environment.

Statistical tests are conducted to check potential issues of multicollinearity and heteroscedasticity. We calculate the VIFs of socio-demographic, housing, location and sub-district variables using the single-level regression models. The large VIF is found to be 1.77 for the variable of Percentage of migrants, which is far lower than a conventional threshold of ten. Therefore, the issue of multicollinearity is negligible. Heterogeneity is to a large extent controlled by our multilevel modelling approach in which residuals for individuals located in different sub-districts could be different. With respect to spatial autocorrelation, we calculated the Moran's I statistic of the sub-district level model residuals for our preferred model specification (Model 4). The resultant Moran's I is about 0.05 with a p-value of 0.21, indicating an absence of spatial autocorrelation.

Two extra models are also estimated to check the robustness of our estimates on the impacts of neighbourhood satisfaction and perceived relative income on life satisfaction (Table 4). In our first exercise, the geocoordinates (Easting and Northing) of each respondent's residence and their first-order interaction are included in Model 4 to capture the potential impacts of fine-spatial granular unobservables on life satisfaction. The locational variables and sub-district level variables become insignificant, which is expected due to the high correlations between them and the residence geocoordinates. However, the key socio-demographic and housing-related variables, and all of the subjective assessments towards relative income and neighbourhood attributes remain statistically significant. In the second exercise, we collapse the five-category ordinal response variable to a three-category one by combining the responses of 'very satisfied' and 'satisfied' into one category, and the responses of 'very unsatisfied' and 'unsatisfied' into another. This is to address the issue that

only a small proportion of respondents reported 'very (un)satisfied'. The estimation results are listed under the label of *Robust 2*. Some changes in estimation results are observed, for example, age becomes insignificantly associated with life satisfaction while educational attainment becomes significant. Yet, our key findings on the impacts on life satisfaction of neighbourhood satisfaction and perceived relative income still hold.

[Table 4 about here]

5. Discussion

Life satisfaction is associated with various factors, ranging from socio-demographic characteristics to income inequality, from physical environment to residential satisfaction (Ballas, 2013). However, little research has integrated them in a comprehensive study. Even fewer studies have examined the fine-grained geographical variations of life satisfaction and explored its determinants, particularly in developing countries (Bardhan et al., 2015; Wang & Wang, 2016). This study develops a broad analytical framework to investigate the effects on life satisfaction of both objective and subjective measures at the fine geographical scale in a Chinese megacity. It firstly presents the spatial distributions of diversified evaluation of residential environment and life satisfaction at the sub-district scale in urban Beijing. It further investigates the impacts on life satisfaction of subjective neighbourhood evaluation and perceived relative income, and how they mediate the relationship between objective measures and life satisfaction.

A sequence of multilevel ordinal logistic models has been estimated to explore the determinants of life satisfaction in urban Beijing. Across various model specifications, socio-demographic variables including age, marital status, family structure, and housing-related attributes including housing tenure and living space are significant predictors in life satisfaction, which are consistent with previous studies on life satisfaction in China and

across the world (e.g. Smith et al., 2004; Greif, 2015; Ma et al., 2017). Migrants are discriminated against in terms of access to local services and benefits, as a result of the household registration system and the institutional distribution of social benefits. Migrants report a significantly lower level of life satisfaction compared with local residents. This is in accordance with the findings reported by Liu et al (2017). Such inequality imposed by institutional discrimination needs more attention from policy makers as new policies should be initiated to promote an equal and inclusive urban development.

Our findings confirm the relative income or social comparison hypothesis (e.g. Clark et al., 2008; Knight et al., 2009; Huang et al., 2016), as an individual's perceived income compared to that of peers in neighbouring areas and to his/her past income are both significant factors in predicting life satisfaction. To put these impacts in respect, increasing an individual's perceived income relative to his/her peers by two standard deviations, that is from 2.47 to 4.07 on a five-point Likert scale, is associated with about 253% increase in the odds of reporting a higher level of life satisfaction, holding all other variables constant. Previous studies measure relative income by using the deviation of a person's income from the average income in a particular area or among a social group (Clark et al., 2008). Such an indicator is vulnerable to measurement errors. Another important finding is that absolute income is not statistically significantly associated with life satisfaction once perceived relative income is controlled for. This might indicate that absolute income does not affect life satisfaction *directly* but *indirectly* through its impact on perceived relative income. Satisfactions with key neighbourhood domains are another set of significant predictors of life satisfaction, whilst most of the objective sub-district characteristics are not. However, the neighbourhood locational variables show significant correlations with life satisfaction in our preferred model specification (Model 4). Our results suggest that the subjective neighbourhood evaluation exerts greater influences on life satisfaction than the objective

residential environment, consistent with the findings in prior studies (Phillips et al., 2005; Ibem & Amole, 2013).

6. Conclusion

Using a large-scale survey data in urban Beijing in 2013, this study for the first time presents the spatial distribution of neighbourhood satisfaction and life satisfaction at the fine sub-district scale, and then explores the roles of socio-demographic variables, housing conditions, health, contextual variables, perceived relative income, and subjective evaluation of residential environment in predicting life satisfaction. A Bayesian multilevel ordinal response modelling framework is employed to capture the two-level structure of the survey data and the ordinal nature of the outcome variable of life satisfaction. Our key findings are in several aspects. First and foremost, perceived relative income and satisfaction with neighbourhood characteristics including safety, physical environment, social environment and travel convenience are all statistically significantly correlated with life satisfaction. Moreover, these subjective measures have stronger predictive powers than the objective variables, and they mediate the relationship between life satisfaction and objective measures. For instance, absolute income becomes insignificant once perceived relative incomes are controlled for, suggesting that absolute income influences life satisfaction indirectly through the effects of perceived relative income. With respect to socio-demographic variables, age, marital status, family structure and residential status are robust factors influencing life satisfaction. Housing-related factors including housing tenure, housing types and floor areas, also play important roles in predicting life satisfaction.

This research has important policy implications. First, life satisfaction is strongly influenced by perceived relative income rather than absolute income; people with low income are more likely to improve their life satisfaction with additional income compared with their

past. Policies aiming at reducing income inequality across different social groups could improve overall life satisfaction in the long run. Second, migrants are restricted in getting access to various local services and benefits, and are more likely to report lower levels of life satisfaction than local residents. The government should pay more attention to migrants in urban/community planning and public services provision, and further reform the *hukou* institution to improve migrants' integration in the urban society. Third, commuting time is demonstrated to be significantly associated with life satisfaction; people with longer commuting time tend to be less satisfied with life. As Beijing has experienced rapid urban expansion and spatial restructuring process, people have to endure longer travelling distance and spend more time on commuting, which have detrimental impacts on life satisfaction. Compact planning measures are needed to improve the job-housing balance. Moreover, at the neighbourhood scale, safety, physical environment, social environment, and travel convenience, particularly in the inner suburban area or urban fringe of Beijing, need to be improved, as they significantly influence residents' life satisfaction. A combination of urban planning measures and policies needs to be carried out to make the city more livable and sustainable.

The study has some limitations. First, our data are cross-sectional in nature, which only support the association between neighbourhood satisfaction and life satisfaction. Campbell's model (1976) indicates residential satisfaction is one dimension of life satisfaction, and it is likely that the former leads to the latter. However, without panel data, we are unable to test the causal effect of neighbourhood satisfaction on life satisfaction. We cannot rule out other interpretations, for example, more optimistic people are more likely to express satisfaction with both neighbourhood environment and overall life. Second, our survey did not collect data on respondents' social networks which are an important component of life. Therefore, we are unable to discuss the role of social networks in

influencing life or neighbourhood satisfaction. Despite these limitations, the study provides

important insights on residential environment and life satisfaction in urban China.

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Tables

Table 1. Descriptive summaries of variables in the analysis

Variable names	Description	Proportions /Mean(sd)
Life satisfaction (%)	1 = Very unsatisfied	0.56
	2 = Unsatisfied	4.93
	3 = Fair	31.7
	4 = Satisfied	56.4
	5 = Very satisfied	6.39
Age	age	34.6(11.8)
Income (RMB)	Family monthly income	10421(9319)
Education (%)	Primary	10.2
	Secondary	26.6
	Tertiary	63.2
Female (%)	Male as base category	50.6
Marital status (%)	Married	60.6
Employment (%)	Employed	84.8
Child presence (%)	Household with child under 6	13.6
Residence status (%)	Local residents (non-migrants)	64.3
Housing tenure (%)	Owners	50.8
Housing type (%)	Commodity housing	45.1
	Affordable housing	22.9
	Work-unit housing	11.9
	Self-built housing	19.9
Housing area (%)	80+	44.4
	40-80	33
	<40	22.6
Commuting time	One-way commuting time in minutes	35.8(24.4)
Not moved (%)	Not moved in the current residence	73
Residence length	The length of living in the current residence if moved since 2009	2.44(1.43)
Log of distance to green park	Log of distance to the nearest green park	3.41(2.75)
Log of distance to city centre	Log of distance to city centre	5.89(2.84)
Log of distance to railway station	Log of distance to the nearest railway station	1.96(2.11)
Percentages migrants	Proportions of migrants in each district	37.5(17.9)
Percentages homeowners	Proportions of home owners in each district	56.0(15.9)
Percentages buildings after 2000	Proportions of buildings built after 2000 in each district	47.2(21.2)
Self-rated health	Self-rated health status ranging from 1 being very unhealthy to 5 being very healthy	3.87(0.74)
Perceived income relative to peers	Satisfaction with income compared with those of peers in the neighbourhood	3.27(0.80)
Perceived income relative to previous one	Satisfaction with income compared with previous income	3.30(0.79)

Satisfaction with (neighbourhood characteristics)	Safety	3.32(0.71)
	Physical environment	3.37(0.74)
	Social environment	3.37(0.67)
	Travel convenience	3.49(0.73)

Note: RMB = renminbi, official Chinese currency.

Table 2. Estimation results with socio-demographics and objective contextual variables

	Model 1			Model 2		
	Median	2.5%	97.5%	Median	2.5%	97.5%
Age	-12.19*	-17.85	-6.413	-12.84*	-18.46	-7.162
Age squared	10.57*	5.743	15.36	10.76*	5.786	15.54
Income	0.328*	0.204	0.451	0.332*	0.206	0.466
Education						
Primary	-0.048	-0.25	0.165	-0.042	-0.25	0.18
Tertiary	0.155*	0.019	0.295	0.151*	0.009	0.296
Female	0.053	-0.061	0.167	0.052	-0.058	0.166
Married	0.308*	0.155	0.469	0.311*	0.147	0.471
Employed	0.197	-0.014	0.393	0.202*	0.001	0.404
Child presence	-0.214*	-0.38	-0.049	-0.208*	-0.39	-0.029
Residence status	0.442*	0.299	0.582	0.444*	0.297	0.588
Housing tenure	0.268*	0.116	0.422	0.261*	0.108	0.412
Housing type						
Work-unit housing	0.139	-0.065	0.349	0.168	-0.046	0.382
Commodity housing	0.404*	0.259	0.547	0.396	0.247	0.542
Self-built housing	0.001	-0.167	0.172	-0.003	-0.176	0.175
Housing area (m^2)						
>80	0.248*	0.105	0.388	0.263*	0.133	0.398
<40	-0.022	-0.192	0.138	-0.028	-0.193	0.141
Commuting time	-0.311*	-0.447	-0.18	-0.312*	-0.442	-0.182
Not moved	0.267*	0.067	0.47	0.256*	0.058	0.456
Duration of residence	0.079*	0.011	0.15	0.078*	0.01	0.148
Log of distance to green park				-0.088	-0.273	0.1
Log of distance to city centre				0.234*	0.071	0.403
Log of distance to railway station				-0.26*	-0.436	-0.086
Percentages migrants				-0.041	-0.33	0.258
Percentages homeowners				0.074	-0.17	0.319
Percentages buildings after 2000				0.113	-0.113	0.329
a_1	-4.028*	-4.526	-3.559	-4.053*	-4.532	-3.561
a_2	-1.644*	-1.964	-1.308	-1.668*	-1.992	-1.333
a_3	0.828*	0.506	1.148	0.808*	0.492	1.133
a_4	4.299*	3.951	4.647	4.286*	3.948	4.618
District-level variance	0.132*	0.079	0.206	0.121*	0.068	0.201
WAIC	9977			9974		
Difference in WAIC [std.error]				3.12 [6.98]		

Table 3. Model estimation results with perceived relative income and neighbourhood satisfaction

	Model 3			Model 4		
	Median	2.5%	97.5%	Median	2.5%	97.5%
Age	-3.202	-8.814	2.581	-3.757	-9.674	2.208
Age squared	7.975*	2.863	12.87	6.965*	1.921	12.119
Income	-0.057	-0.186	0.072	-0.054	-0.186	0.077
Education						
Primary	-0.011	-0.233	0.216	-0.034	-0.257	0.182
Tertiary	0.049	-0.099	0.199	0.045	-0.105	0.197
Female	0.005	-0.115	0.126	0.015	-0.105	0.137
Married	0.278*	0.109	0.447	0.284*	0.115	0.454
Employed	-0.014	-0.225	0.198	-0.021	-0.235	0.192
Child presence	-0.183*	-0.371	-0.001	-0.17*	-0.351	-0.002
Residence status	0.453*	0.3	0.608	0.45*	0.294	0.604
Housing tenure	0.242*	0.085	0.399	0.268*	0.107	0.428
Housing type						
Work-unit housing	0.188	-0.032	0.413	0.208	-0.017	0.438
Commodity housing	0.224*	0.071	0.384	0.189*	0.027	0.351
Self-built housing	0.051	-0.127	0.241	0.024	-0.158	0.201
Housing area (m^2)						
>80	0.185*	0.034	0.336	0.156*	0.01	0.303
<40	-0.094	-0.269	0.076	-0.085	-0.268	0.097
Commuting time	-0.195*	-0.334	-0.053	-0.167*	-0.307	-0.026
Not moved	0.145	-0.068	0.356	0.15	-0.064	0.365
Duration of residence	0.031	-0.044	0.105	0.033	-0.041	0.106
Log of distance to green park	-0.102	-0.298	0.085	-0.096	-0.292	0.096
Log of distance to city centre	0.138	-0.033	0.306	0.115	-0.06	0.292
Log of distance to railway station	-0.26*	-0.437	-0.086	-0.185*	-0.366	-0.001
Percentages migrants	-0.04	-0.331	0.243	-0.008	-0.297	0.26
Percentages homeowners	0.11	-0.132	0.339	0.107	-0.125	0.325
Percentages buildings after 2000	0.211	-0.009	0.434	0.233*	0.019	0.442
Self-rated health	1.48*	1.35	1.614	1.388*	1.258	1.523
Perceived income relative to peers	1.315*	1.15	1.48	1.26*	1.095	1.427
Perceived income relative to previous one	0.938*	0.777	1.093	0.861*	0.702	1.017
Satisfaction with neighbourhood:						
safety				0.344*	0.199	0.498
physical environment				0.205*	0.052	0.36

social environment				0.219*	0.072	0.365
travel convenience				0.288*	0.152	0.42
a_1	-5.61	-6.136	-5.12	-5.765	-6.31	-5.25
a_2	-2.935	-3.287	-2.581	-3.036	-3.415	-2.668
a_3	0.154	-0.186	0.482	0.115	-0.244	0.462
a_4	4.455	4.076	4.817	4.497	4.108	4.891
District level variance	0.094	0.047	0.163	0.084	0.041	0.147
WAIC	8387			8259		
Difference in WAIC (Model 3 – Model 2) [std.error]				1587.3* [83.2]		
Difference in WAIC (Model 4 – Model 3) [std.error]				127.5* [24.9]		

Table 4. Robust analyses with different model specifications

	Robust 1			Robust 2		
	Median	2.5%	97.5%	Median	2.5%	97.5%
Age	-3.582	-9.428	2.154	-0.182	-6.792	6.351
Age squared	6.946*	2.06	12.16	5.387	-0.346	10.96
Income	-0.062	-0.195	0.077	-0.129	-0.284	0.026
Education						
Primary	-0.026	-0.253	0.192	0.019	-0.213	0.253
Tertiary	0.038	-0.115	0.184	0.163*	0.004	0.324
Female	0.011	-0.108	0.133	-0.021	-0.157	0.11
Married	0.277*	0.114	0.441	0.377*	0.19	0.569
Employed	-0.015	-0.219	0.195	0.14	-0.097	0.369
Child presence	-0.164	-0.35	0.021	-0.195	-0.406	0.017
Residence status	0.447*	0.291	0.606	0.438*	0.271	0.598
Housing tenure	0.273*	0.102	0.443	0.3*	0.118	0.481
Housing type						
Work-unit housing	0.193	-0.024	0.414	0.071	-0.162	0.305
Commodity housing	0.178*	0.012	0.332	0.277*	0.107	0.448
Self-built housing	0.022	-0.166	0.212	0.006	-0.195	0.199
Housing area (m^2)						
>80	0.156*	0.005	0.305	0.162	-0.006	0.332
<40	-0.098	-0.279	0.076	-0.089	-0.282	0.096
Commuting time	-0.163*	-0.299	-0.018	-0.139	-0.297	0.018
Not moved	0.162	-0.055	0.375	0.19	-0.037	0.412
Duration of residence	0.036	-0.037	0.11	0.042	-0.039	0.125
Log of distance to the nearest green park	-0.134	-0.331	0.06	-0.002	-0.208	0.206
Log of distance to the city centre	0.139	-0.038	0.314	0.067	-0.112	0.242
Log of distance to the nearest railway station	-0.121	-0.31	0.063	-0.118	-0.309	0.068
Percentages migrants	-0.077	-0.368	0.193	-0.054	-0.36	0.237
Percentages homeowners	0.076	-0.156	0.297	0.058	-0.19	0.298
Percentages buildings after 2000	0.202	-0.011	0.417	0.178	-0.055	0.414
Perceived health	1.39*	1.254	1.531	1.217*	1.075	1.36
Perceived relative income	1.257*	1.087	1.426	1.253*	1.071	1.437
Perceived previous income	0.864*	0.708	1.03	0.849*	0.678	1.019
Satisfaction with neighbourhood:						
safety	0.346*	0.203	0.489	0.341*	0.184	0.5
physical environment	0.202*	0.053	0.346	0.131*	0.037	0.299
Social environment	0.227*	0.073	0.38	0.281*	0.118	0.447
Travel convenience	0.281*	0.15	0.417	0.304*	0.152	0.451

Easting	0.147	-0.023	0.316			
Northing	0.221*	0.032	0.409			
Easting×Northing	0.11	-0.24	0.447			
a_1	-5.765*	-6.293	-5.262	-2.681*	-3.064	-2.292
a_2	-3.038*	-3.392	-2.683	0.439*	0.084	0.808
a_3	0.115	-0.226	0.457			
a_4	4.502*	4.132	4.873			
District level variance	0.278	0.187	0.376	0.296	0.192	0.404
WAIC	8258			6379		

Figures (colour figures for the online version only)
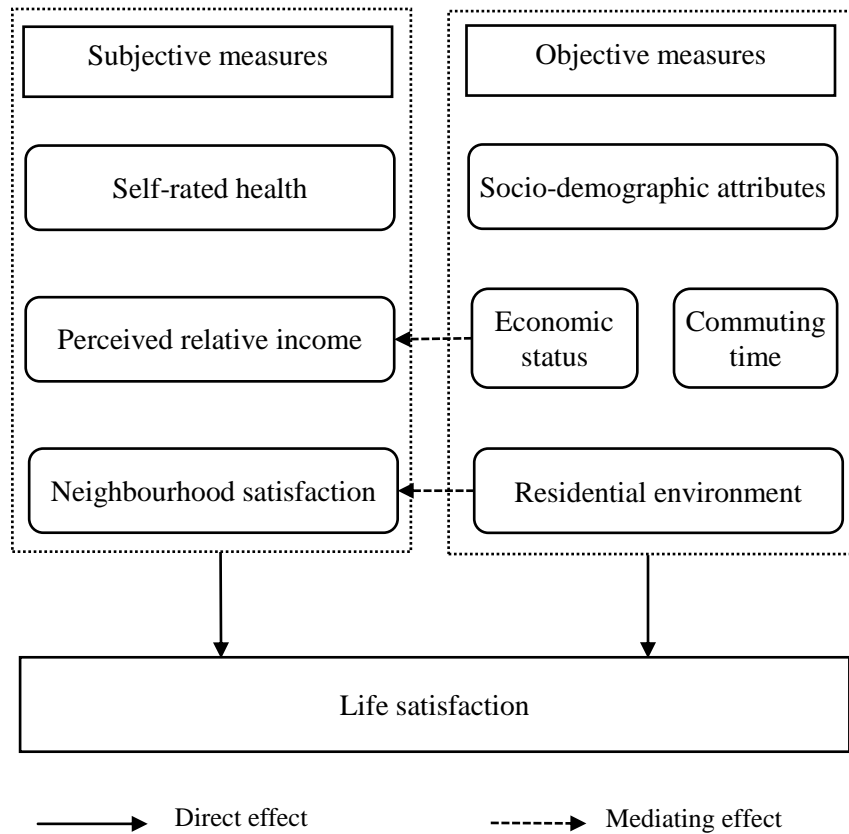
Fig.1. Conceptual framework of the study
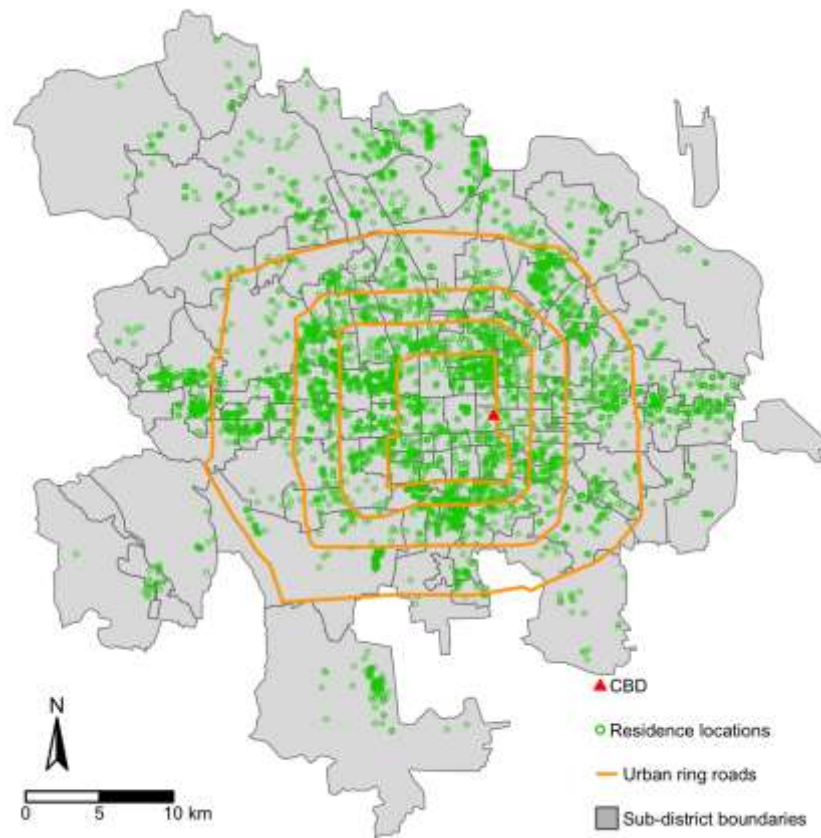
Fig. 2. Research area and sample distribution
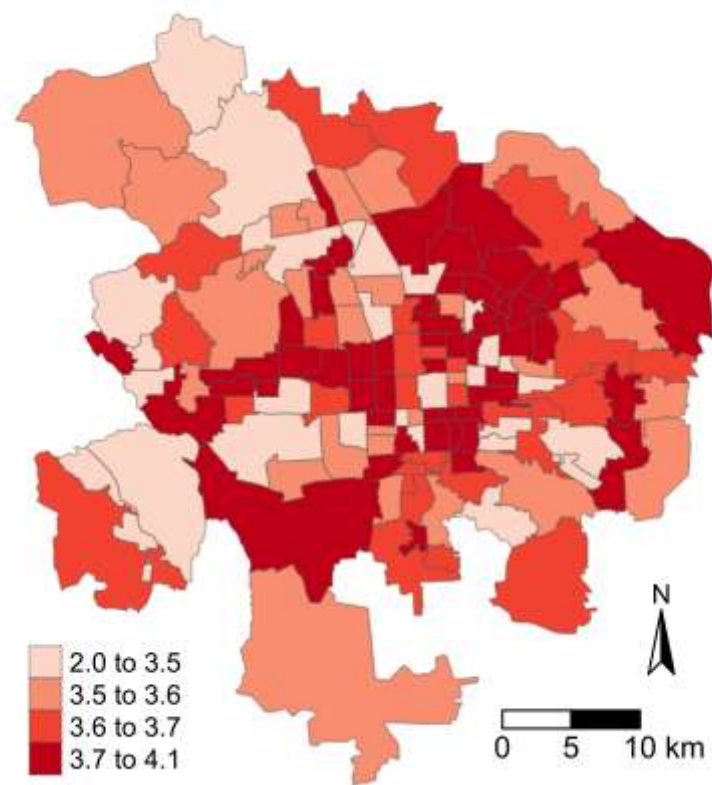
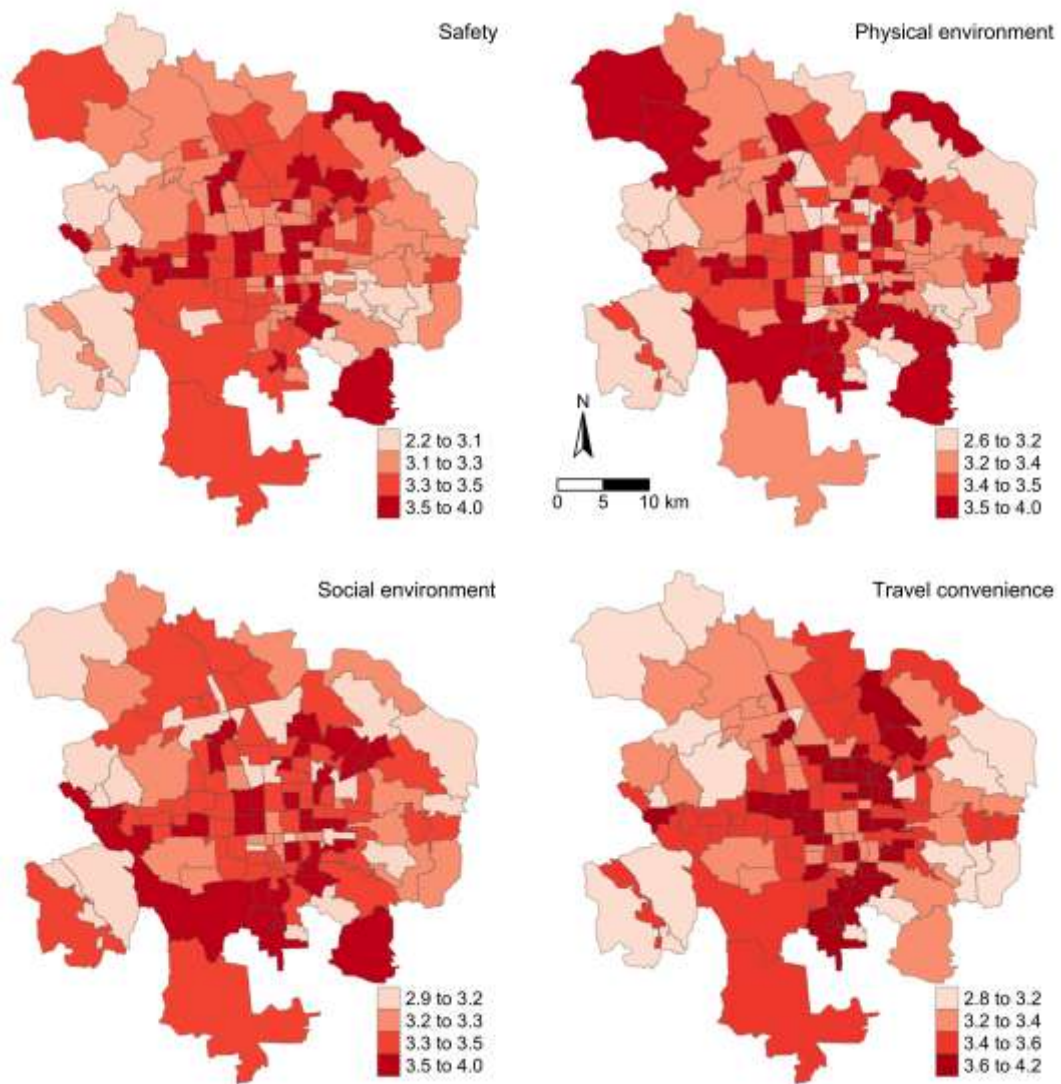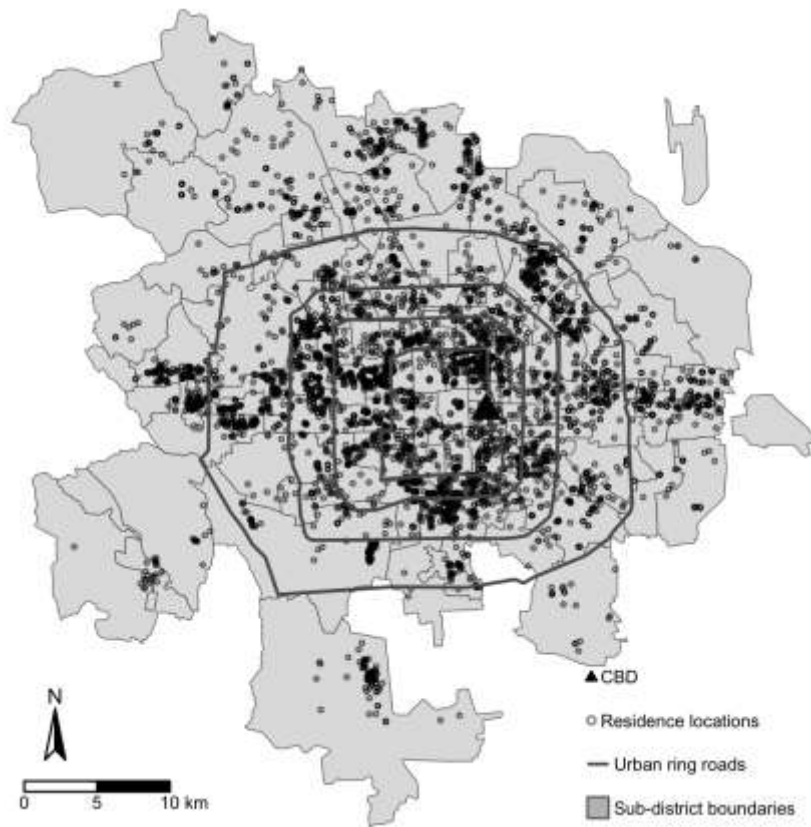Fig.3. Spatial distribution of life satisfaction at the sub-district scale in urban Beijing

Fig.4. Spatial distribution of satisfaction with neighbourhood characteristics at the sub-

district scale in urban Beijing

Black and white Figures (for printed version)
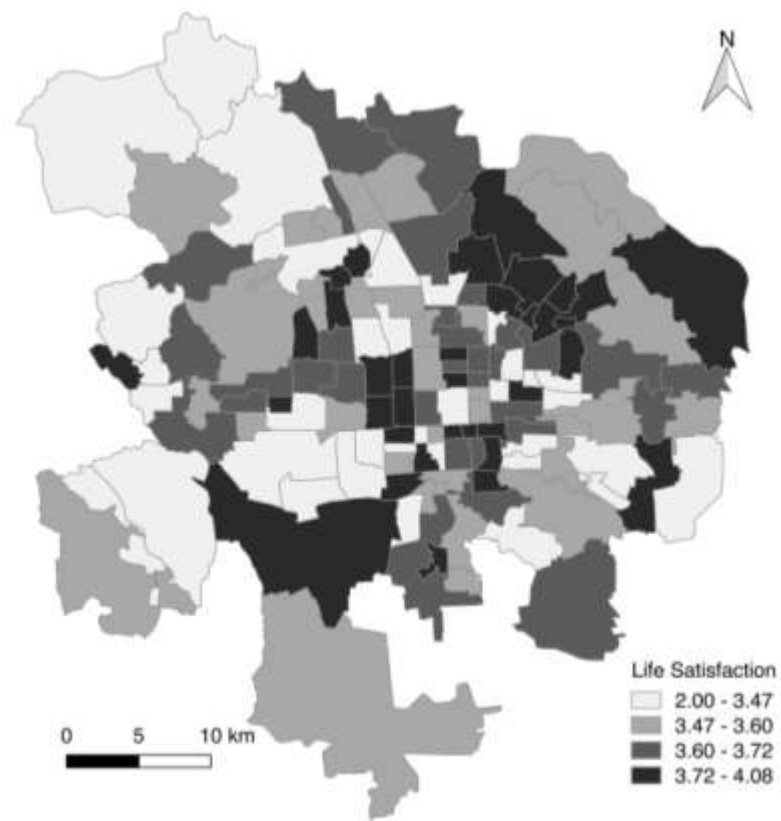
Fig. 2. Research area and sample distribution

Fig.3. Spatial distribution of life satisfaction at the sub-district scale in urban Beijing

Fig.4. Spatial distribution of satisfaction with neighbourhood characteristics at the sub-

district scale in urban Beijing