Spatial Economics Research Centre

SERC DISCUSSION PAPER 134

Does Better Rail Access Improve Homeowners' Happiness?: Evidence Based on Micro Surveys in Beijing

Wenjie Wu (SERC, Urban Studies, School of Social and Political Sciences, University of Glasgow)

April 2013

This work is part of the research programme of the independent UK Spatial Economics Research Centre funded by a grant from the Economic and Social Research Council (ESRC), Department for Business, Innovation & Skills (BIS) and the Welsh Assembly Government. The support of the funders is acknowledged. The views expressed are those of the authors and do not represent the views of the funders.

Does Better Rail Access Improve Homeowners' Happiness?: Evidence Based on Micro Surveys in Beijing

Wenjie Wu*

April 2013

* SERC, London School of Economics and Political Science; Urban Studies, School of Social and Political Sciences, University of Glasgow

Acknowledgements
I am grateful to Steve Gibbons and Paul Cheshire. I thank Brett Day, Francesca Cornaglia, Olmo Silva, Henry Overman, and seminar participants at the London School of Economics and University of Glasgow for helpful comments and suggestions.

Abstract

Development of urban transport infrastructures is a key policy focus---particularly in countries like China which have experienced fast urbanisation over the past decade. While existing studies provide marginal values for rail access on the real estate market, little is known about the consequences of local public goods improvements for homeowners' subjective wellbeing using reported happiness data. This paper uses a difference-in-difference method to empirically measure the impact of rail access on homeowners' happiness. My identification strategy takes advantage of micro happiness survey data conducted before-and-after the opening of new rail stations in 2008 Beijing. I deal with the potential concern about the endogeneity in sorting effects by focusing on "stayers" and using non-market (fang gai) housings with pre-determined locations. I find the significantly heterogeneity in the effects from better rail access on homeowners' happiness with respect to different dimensions of residential environment. The welfare estimates suggest that better rail access provided substantial benefits to homeowners' happiness, but these benefits have strong social-spatial differentiations. These findings add to the evidence that transport improvement has an important role to play in influencing local residents' subjective wellbeing.

JEL Classifications: D60, H41, R41

Keywords: Happiness; transport improvement; Geographical Information System; Wellbeing; China

1 Introduction

Transport infrastructure is undoubtedly believed as an important part of government investment program and is of great importance for homeowners' living experiences. Many countries like China are implementing transport policies to invest in new rail transit constructions and improve poor rail access conditions. Recently, four new rail transit lines were opened around 2008 Beijing, with the total investment of over 40 billion CNY (1GBP≅10 CNY). From a policy perspective, this transport improvement program is conducted against the backdrop of broad public conversations of residents' happiness in Beijing through the "Towards Livable City" initiative since 2004. This agenda has driven important changes in transport services in order to reflect several key outcomes for people's residential happiness with respect to "commuting convenience", "living convenience", "traffic pollution", "traffic safety", and "social environment" (Zhang et al, 2006). The question then arises as to whether these kinds of objectives can be met in the 2008 transport improvement context, where policymakers tend to judge the success of transport investment program solely on the basis of economic census data. While most researchers value the amenity benefits of rail access in the real estate markets, little is known about whether this is mirrored in higher levels of happiness with respect to particular dimensions of residential environment.

In this paper, I provide an alternative (direct) way of estimating the impact of the transport improvement program, identified by rail access changes, on homeowners' happiness (rather than e.g. house price or looking at other economic outcomes)[1]. My

[1] Recall that this paper does not attempt to identify the planning effects of new stations on people's happiness and related housing price changes, residential mobility or neighbourhood dynamics. Instead, this paper typically focuses on examining the direct impact of the increased station proximities on homeowners' happiness, as opposed to the indirect effect from the fact that local residents may become wealthier because of the increased values of their homes.

outcome measures are based on detailed and repeated survey responses that allow specifications about happiness with respect to different dimensions of residential environment---commuting and living convenience[2], social environment, traffic pollution and safety, rather than only one general life happiness indicator. My main goal is to consider two related research questions, that is: i) To what extent are happiness in specific residential aspects, amongst homeowners, linked to rail access based on measures of residence-station distance changes? ii) To what extent are homeowners' perceptions of better rail access varied based on their different social backgrounds (i.e., income and age)? To answer these questions I aggregate the micro surveys into an area panel, which contains a rich set of repeated happiness responses and individual background characteristics, and which I have matched to rail access on homeowners' places of residences. To my knowledge, this is the first application of this type of analysis to the happiness studies in the developing countries. I deal with the central problem of the potential endogeneity in sorting effects by focusing on "stayers"[3] and by using the non-market housing---a legacy from the socialist welfare housing system with pre-determined locations and non-market transactional rules. Using the difference-in-difference style estimation strategy, I will first run the regressions for the whole sampled "stayers", and then for the non-market housing sampled homeowners, to further verify the impact of rail access changes on happiness before-and-after the building of new rail transit lines.

Another contribution of this paper is to explore the potential welfare benefits of improvements in rail access on the Chinese homeowners' happiness with respect to different dimensions of residential environment. By measuring the marginal utility of

[2] See detailed description of the definition of each happiness indicator in the appendix A.
[3] Note that the term of "stayers" here means homeowners who were living at their homes before the transport was improved.

rail access and the marginal utility of income, compensating variation between income and rail access can be calculated. This welfare measure has recently been used elsewhere in the literature to evaluate subjective benefits of air quality based on reported happiness data and have useful implications in the benefit-cost analyses for evaluating public policies (see Luechinger, 2009; Frey et al., 2010). This paper improves on previous studies by quantifying both of the average and distributional benefits of the transport improvement program.

The remainder of this paper is structured as follows. Section 2 reviews related literature. Section 3 describes the data and institutional background. Sections 4 explains the methodology. Section 5 presents the main findings on the impact of rail access changes and homeowners' happiness with respect to different dimensions of residential environment. Section 6 monetises the welfare effects of transport improvement program. Section 7 concludes.

2 Literature review

Researchers of sociology and geography have often used survey data to elicit household preferences for public facilities (Lu, 1999; Parkes et al., 2002; Mohan and Twigg, 2007; Adriaanse, 2007; Permentier et al., 2011), but analysis of the perceived assessments for transport accessibility remains a relatively unexplored research field in urban economics. In fact, a large volume of economic literature has focused on examining the net benefits of rail access by using the reveal preference techniques---like the hedonic valuation approach. Assessment of these net benefits from changes in rail access is usually valued based on nearby land and housing prices (Cheshire and Sheppard, 1995; Bowes and Ihlanfeldt, 2001; Gibbons and Machin, 2008; Wu, 2012). However, one potential concern of this reduced-form approach is that one cannot separately identify the direct and indirect benefits associated with rail access. Whilst it is true that property-price outcomes matter, there may be wider aspects of socio-psychological developments that are at least as important as price premiums in evaluating the amenity benefits.

Using perceived happiness survey questions, economists can better single out the direct relationship between local public goods and people's subjective wellbeing (often loosely called as happiness[4]). For example, Luechinger (2009) finds the negative effect of air pollution on happiness based on individual survey data in Germany. Cornaglia and Leigh (2011) use an area panel data from Australia to estimate the direct impact of changes in crimes on mental wellbeing of resident non-victims. They find that crime---especially the type of violent crime rates have a negative impact on people's mental wellbeing. Gibbons and Silva (2011) find a strong impact of school quality, measured by test scores, on parents' happiness about education effectiveness based on the longitudinal survey of young people in England. Indeed, recent literature in happiness economics also point out that the estimated happiness effects can avoid some problems inherent in the hedonic method (see Frey et al., 2009 for a review). For example, the assumptions of the happiness approach can be less restrictive than the hedonic approach since it is not based on observed behaviours. Recall that the hedonic approach is based on the underlying assumption that housing and labour markets are in fully spatial equilibrium. To meet this assumption, households should have enough market information, the land and housing supply should be sufficient, and the moving costs in the housing and labour markets should be very low (Freeman, 2003). Yet in reality, these assumptions associated with

[4] Happiness is considered as a fundamental measurement of human subjective wellbeing (Campbell et al, 1976). It is naturally the topic of socio-psychology, medicine, and health research, and has recently expanded its focus on people's happiness about residential environment. See Layard (2005) and Frey et al (2008) for details.

the hedonic approach cannot be fully meet at certain local contexts. Conversely, the happiness approach can explicitly capture utility gains or losses even without such market equilibrium assumptions. Though the self-reported happiness data may not as accurate as housing transaction data, it is still an effective way to evaluate local public goods in utility terms (Blanchflower and Oswald, 2004; Krueger and Schakde, 2007; Oswald and Wu, 2010). By measuring the marginal utility of a specific local amenity and the marginal utility of income, the trade-off ratio between income and that particular local amenity can be calculated. Indeed, this happiness approach has recently become one of the promising development in economics and has been used elsewhere to evaluate inflation and employment (Di Tella et al., 2001), as well as a wide range of public goods like air quality (Luechinger, 2009; Frey et al., 2010) and slum improvements (Takeuchi et al., 2008). My analysis adds to this growing literature by providing new evidence on the happiness effects of the transport improvement program[5].

3 Institutional Settings and Data

In this section I first outline the institutional background about the housing reform in China. I then go on to explain the micro data involved into the empirical analysis.

3.1 The housing reform in urban China

To better understand the exogenous nature of non-market (*fang gai*) housing, this section briefly introduces the housing reform policy background, with the key focus on the non-market (*fang gai*) housing in China.

[5] It is certainly the case that combined estimates from both of the hedonic valuation approach and the happiness approach would offer more precise information about the rail access effects, but collection of micro housing transaction data with precise geographical characteristics would be very costly and not publicly accessible in Beijing. Some comparisons of hedonic and wellbeing measures can be found in Van Praag and Baarsma (2005), Gibbons and Silva (2011), among others.

Before the housing reform policy launched in the 1990s, no housing market was existed and housing was not a commodity in China (see Wu et al., 2013 for details). All housing units were provided by work unit (*Danwei*) to their employees as employee welfare. Under the centralized planning-economy era, urban lands were owned by the state and were allocated to work units. A work unit typically constructed housing units on its allocated lands, and then assigned them to its employees based on their job ranking and working life length, etc (Fu et al., 2000). All work-unit housings are owned by the employers, and their employees did not have to pay or only paid very low fees for renting. All urban workers did not need to choose their residential locations.

In the reform era, housing market has been gradually established. Real estate developers began to construct and sell market housing to households. Meanwhile, the central government of China stopped to offer the lands for constructing work-unit housings based on the 1998 housing reform policy (see Huang and Clark, 2002). But most work units continued to provide heavy subsidized housings through the “internal housing market” (Sato, 2006). All of these work-unit housings were privatized by selling to their employees at low prices and were commonly called the non-market (*fang gai*) housings. Due to the historical policy reasons mentioned above, the pre-determined location nature of non-market (*fang gai*) housings can be regarded as exogenous. Thus the baseline robustness test examined in this context is to use the sampled non-market housing homeowners to account for potential endogeneity in residential sorting. One thing to note is that, the effect of work-unit housing privatization may not impose an immediate wealth transfer. This is because that although work units transferred the ownership to their employees, resale of non-market (*fang gai*) housings is not allowed. Recently, this non-transaction rule has been gradually relaxed in some Chinese cities, however, the actual transition of *fang gai* housings into fully market housings in Beijing is restrictedly limited[6]. Notably, homeowners who hold the non-market housing tenure may not actually live in their non-market housings. Thus in this study, I only focus on the sampled homeowners who hold the non-market housing tenure and currently living in the non-market housing during my study period. It is also worth noting that the impact of rising housing prices in the marketplace is not significant for non-market housing homeowners' happiness (assuming their housing costs do not change). As such it is reasonable to expect that non-market (*fang gai*) housing homeowners have more reasons to gain benefits when experienced better access to local amenities.

3.2 Data

My analysis is estimated using households' happiness data from Beijing, China. Beijing is largely a mono-centric city in terms of population density, land and housing price gradients (Zheng and Kahn, 2008). The *JianGuoMenWai* area is conventionally viewed as the central business district (CBD). The main Beijing' urbanized area is within the No.5 ring road, with a small proportion located outside the No. 5 ring road in the north and east directions. This area comprises more than 60% percent of the metropolitan population with just over 10 million residents in 2000.

This study adopts a unique micro survey dataset of Beijing residents that include two large-scale surveys conducted in 2005 and in 2009 respectively. The data sample for each survey is about 11,000 respondents respectively[7]. The surveys provide rich information on a household's demographic characteristics and residential happiness

[6] In some cases, the sale of former work-unit housings had additional limitations like the owner can sale the property back to the work-unit or other employees in this work-unit.
[7] The effective response rate is about 79% in the 2005 survey and 72% in the 2009 survey.

conditions[8]. For each member of the household roster, the survey reports age, income[9], education, family size, job rank, place of residence, commuting time and modes. The household's ownership identity is given[10]. In addition, the surveys document detailed living conditions such as the housing's type (non-market housing or market-housing), the duration living in this residential location, housing size, as well as local residents' happiness in specific residential aspects, such as commuting convenience, traffic safety, social environment, traffic pollution, and living convenience. There are several key characteristics of this survey dataset: i) It has large sample size that covered Beijing's main urbanized area instead of selected sample areas; ii) Its samples were selected randomly and proportional to the population at each zone (*jiedao*). Zone is the fundamental administrative organization and census unit in China. While zones generally are aggregations of residential places, they do not reflect the boundaries of political jurisdictions like the developed countries. Zones are intended to be similar areas with respect to general socio-demographic characteristics; iii) The unit of the survey was Beijing households, excluding the floating population or travellers who had been in Beijing for less than six months. Such sampling strategy enables all the respondents to be familiar with their living environment; iv) This micro data appears to be reasonably representative. A comparison of 2005 sampled household demographics with data from the 2005 Beijing Population Survey revealed no significant differences[11]. In the empirical analysis, I will use the sample of the homeowner head ages 18-65 who work and have lived in the current residences for at

[8] The happiness survey questions are shown in the appendix A table.
[9] Note that I have converted the categorized income information into the mid-point value of the respective categorical interval. Since the highest income category is open-ended, I predict the mid-point value of this category by using the sample's normalizing distribution. All monetary values are adjusted by the Beijing consumer price indices and reported as CNY (1GBP≅10CNY).
[10] As for housing property types, about 53.6% households own non-market housing unit in the 2005 survey, and this figure remains stable in the 2009 survey (52.1%). The other households own market housing units. The survey's non-market housing ownership ratio tells a consistent story with the overall non-market housing ownership ratio in Beijing.
[11] One potential source of bias resulted from oversampling employees, in order to get households' commuting characteristics.

least five years. This sample restriction can help me to focus on the homeowners independent of job searching and residential sorting concerns. In addition, I am well aware that my sampled homeowners include both public transport users and non-public transport users. It is expected that public transport users might gain more benefits from the new rail transit constructions. However, it would be useful to know if the happiness effects for public transport users were offset by the nuisance effects for everyone else. I will look at the public transport users' happiness results as a special case in the sensitivity analysis.

For the happiness regressions, I use this survey dataset. It has detailed subjective happiness measures that allow model specifications about both of the overall residential satisfaction and happiness with respect to particular dimensions of residential environment---commuting convenience, social environment, traffic pollution and safety[12]. These happiness measures are based on responses to the survey questions (see appendix table 1) on a scale from "1 being very unhappy" to "5 being very happy". One alternative answer was "not familiar" and this was discarded for the purpose of this research.

Recent literature in happiness economics have confirmed the validity of subjective survey data, based on the working assumptions that respondents are able and willing to answer the happiness questions; and there is the significant difference between a respondent with a happiness score of 5 and the one with a score of 4 (see Frey and Stutzer, 2001; Ferrer-i-Carbonell, 2005; Krueger and Schakde, 2007; Oswald and Wu, 2010). However, responses might also be influenced by their emotional feelings, individual experiences and household background, and not only by the characteristics of the residential environment. This is not crucial to the aim of this

[12] The correlations between these happiness measures are very low (coefficients are generally lower than 0.2).

paper. But it is necessary to note that this survey dataset has followed the scientific sampling design and reliable measures to ensure the validity of responses (see Zhang et al., 2006). As a robustness check, I use the Pearson Chi-squared test to confirm the fact that the distribution patterns of key happiness measures have no significant differences across 2005 and 2009 survey samples[13]. Note also that the measures I use here are not general subjective assessments about life happiness, but specific questions on people's perceptions about particular residential aspects. Psychological studies suggest that specific questions are more reliable to reflect what is meant to be measured (Alesina et al., 2004; Kahneman and Krueger, 2006). This is clearly the case when the topic is specific characteristics of residential environment, about which individuals have direct living experiences.

In order to look at the rail transit changes before and after 2008, I aggregate homeowners' happiness evaluations to the $1km^2$ cell-unit groups[14] in two-survey time periods: 2005 and 2009. Then I geographically-coded the newly-opened subway stations in 2008 with the help of the GIS software. The spatial straight-line distance from a cell unit's central point to the closest station is defined as this cell unit's rail access[15]. The rationale behind this is that, it allows me to use the repeated average responses in the same geographical unit, as opposed to repeated individual responses of the same household given the data sample size limitation[16]. Ideally it would be perfect to find a geographical space that can yield perfectly homogeneity in the characteristics of each location. But further disaggregation would not provide enough

[13] The results of Pearson Chi-squared tests are available upon request.
[14] It is necessary to emphasis that I have also tried to aggregate data to higher geographical-unit level like $2km^2$ and even the zone (*jiedao*) level to explore the robustness to the choice of aggregation. The results do not make a markedly difference.
[15] In practice, I have taken care of this measurement to ensure that the closet stations are not inaccessible—for example if separated by the river or expressway, where few crossing points are available.
[16] Another underlying reason is that by matching area rail access changes to repeated area happiness responses, I am therefore able to mitigate the problem of the potential bias from the inconsistent individuals' perceptions about the local geographical area.

sampled residents for the empirical analysis.

In a nutshell, my data is not a panel of people but a panel of areas, and I try to control for potentially endogenous changes to the compositions in response to transport improvements by (a) including changes in the average demographics; (b) using long-term “stayer” sample (homeowner who were living there before transport was improved); (c) using non-market housing homeowner sub-sample with pre-determined residential locations. Once again, the baseline motivation of focusing on the “stayers” sample is to try to identify homeowners in the 2009 sample that have not selected themselves into the area as a result of the transport improvement. When one is reading the results, it is important to keep in mind that this identification strategy cannot fully ensure the people who moved out of the area are being representative. Indeed, there may be concerns that the selected sample are the most or the least responsive to the transport changes. For example, if the people who moved out were the ones who expected to be made unhappy by the transport improvements, the selected “stayers” sample may provide potentially an upper bound to the transport impacts.

Geographical information on location characteristics is taken from a variety of sources as additional controls. School location and performance data comes from the Beijing Municipal Committee of Education. The location of bus stops and expressways are used as proxies for the competing commuting modes, and is obtained by a web-based search from the Beijing Municipal Committee of Transport. Geographical data on the sites of rivers and parks is taken from the Beijing Water Authority and Beijing Municipal Garden Bureau respectively. Crime rates for the number of violent crimes taking place in each zone are obtained from the Beijing Public Security and Safety Bureau. The 2001 City Employment Census provides local employment density. The 2000 City Population Census reports the detailed local demographic characteristics such as population density, education attainment, public housing rent ratio, and the percentage of heritage buildings built before 1949.

3.3 Transport improvement in Beijing

In Beijing, the largest public infrastructure investment project that has taken place recently is the new rail transit constructions. As discussed above, I use the opening of Line 4, 5, 8A, and 10A in 2008 as the transport improvement program[17]. 10 old stations experienced substantial upgrade, but I consider only the 59 new stations here[18]. Indeed, these new subway lines were viewed as the most significant improvement in the Beijing subway network since the 1980s. Figure 1 shows the map of the Beijing subway network before and after the transport improvement. It is expected that the 2008 transport improvement program has altered the residence-station distance for some households, whilst left others unaffected. This provides me with an exogenous change in the distance between homeowners' residential locations and their nearest rail station, from which I can examine the impact of effective rail access changes on homeowners' happiness.

These place-based investments were not chosen randomly. In order to better reflect the sitting process, it is necessary to overview the urban governance structure in Beijing. As the capital city of China, Beijing has three levels of its administrative system: Beijing municipality, district and zone (*jiedao*, it will be referred to as zone thereafter in this study). Following the convention, my study area mainly focuses on the eight urbanized districts (*Dongcheng, Xicheng, Xunwu, Chongwen, Chaoyang,*

[17] The construction of these new subway lines started mainly since 2003, and was completed in and around 2008. It should be noted that Line 5 was temporarily opened at October 2007, but fully opened at the beginning of 2008. To facilitate the interpretation, I treat all the four railway lines opened in 2008. As a robustness check, the results are identical when excluding station sample of the Line 5.

[18] Except for 6 over-ground stations, all the other new stations are in underground status. The results are robust to excluding the over-ground stations and to the inclusion of those 10 upgraded old stations.

Fengtai, Shijingshan, and Haidian) since other districts are predominately rural areas with no rail transit lines. Public investment is highly centralized and controlled by the Beijing municipal government. The zones (*jiedaos*) are only responsible for street cleaning and do not have the voting power for deciding the public infrastructure construction. In other words, the zone functions as a basic geographical area for data collection, not as a political unit using local revenue to offer public goods.

Based on a broad historical document search, the motivations behind the place-based investment decision can be summarized as follows: The primary reason for constructing new rail transit lines is to reduce congestion and meet the rapid growth of the commuting demand. The second aim is to strengthen the connections between the central city and the suburb, especially those emerging super-“bedroom” residential communities in the suburbs (such as *Tiantongyuan, Yizhuang, Daxing,* and *Tongzhou*). Finally, the Beijing municipal government has decided to built one short subway line (Line 8A, with only four stations) to connect the Olympic park with the main rail transit network. I could, in principle, examine the effects of these four new subway lines separately and go further by looking at individual-level new station effect. Nevertheless, I simplify the analysis by treating them as one single event since they occurred at the same time-period in Beijing. Given the importance of the political economy behind the transport improvement, it is important to control the distance to CBD, Olympic Park, large “bedroom” areas as well as other location characteristics that would contribute to the robustness of the rail access effects.

3.4 Characteristics of “treated” and “control” places

In this descriptive analysis section, I show results based on differences in the average happiness changes between affected places and unaffected places by the transport improvement. The results are based on the aggregated dataset, where aggregations are to the cell unit pre-/post the opening of new rail transit lines. There is no significant variation in cell unit-to-station distance within cells.

To be clear from the outset, I term groups of cell units as "treatment" and "control" groups, namely those affected by the transport improvement and those not affected by it. A cell unit is assigned to the treatment group[19] if: It experienced a fall in station-distance with the opening of new rail stations in 2008, and the outcome station-distance in 2008 is now less than 2 km.

I impose the second selecting condition because this study has not attempted to measure how entire metropolitan areas' residents are affected by new rail transit constructions. The choice of a 2 km distance band is based on existing empirical literature and a reasonable walking distance to a station (Gibbons and Machin, 2005). I am implicitly assuming that homeowners' residences that are more than 2km away from rail stations are not affected by the treatment. The rationale behind this is fairly reasonable: even though homeowners' from remote places (no distance reductions or larger than 2km station distance) might also become happier, the main impacts of new stations on homeowners' happiness should be in places near the stations. Owing to the large sample size, I am able to use the 1km and 4km distance band to select the treatment group as a robustness check.

Table 1 summarizes the results of descriptive statistics. I have restricted attention to the whole sampled homeowners. I have also restricted attention to those cell units that are represented in the sample both before and after the transport improvement.

[19] Ideally each $1km^2$ cell unit represents the 1*1km geographical area. However, in a few "treatment" cell units, they also include some homeowners' places of residences that belong to the "control" group. To eliminate this overlap issue, I have used the Thiessen-polygon method to create the cell unit with relative flexible boundaries like the "jigsaw puzzle" based on the GIS software. Of necessity, this method has kept the whole area of each cell unit as $1km^2$ and no spaces among cell units. An alternative strategy is to assign a probability for those "treatment" cell units that contained "controls". To be specific, I define this probability according to proportion of homeowners that would be in each group. For example, if a cell unit contains 15 sampled homeowners, and if 10 out of 15 are the "treatments" and the left are the "controls", then I will assign a probability of 0.75 in this treatment cell unit. As a robustness check, the results are virtually similar by applying this alternative strategy.

Columns (1)–(6) of the table show the average distances to stations, and happiness of five residential aspects, for the full sample, the "treatment" group and the "control" group, before and after the transport changes occurred. Column (7) presents the difference-in-difference estimates based on the raw data[20].

As can be seen from the first row of Table 1, the opening of new rail transit lines did provide distance reduction to stations of 1.2 km for the treatment group, whilst the controls also became slightly closer. This is because my "controls" include places that had received distance reductions but were still beyond 2 km from the nearest station. From row 2 to row 6 of the Table 1, I report the mean value of happiness of each residential aspect before and after the transport improvement. The headline finding is that homeowners' happiness with respect to different dimensions of residential environment in the treatment group experienced effective changes relative to the control group. For example, homeowners are found to become happier about commuting and living convenience, on average, in affected areas after the transport improvement. Homeowners at treated places tend to show less satisfaction about social environment and traffic safety with the building of new rail stations. These results provide preliminary descriptions on the various channels through which the transport improvements might affect happiness. Column (7) tests this more formally by using a diff-in-diff based *t*-test estimator of the differences in the average changes of happiness. The difference in happiness of commuting convenience is strongly significant at the 5% level, showing that homeowners' happiness towards commuting convenience growth to be roughly 6.6% (100*[exp (0.064)-1]) higher, on average, in areas affected by the transport improvement. The relative happiness changes in other residential aspects, though slightly less, are still significant in statistical terms.

[20] This is the estimate $(x_1^{treatment} - x_0^{treatment}) - (x_1^{control} - x_0^{control})$ where x is the variable, period 1 and period 0 represent post-/pre-transport improvement, respectively.

Figures 2-3 provide more evidence on this, which take the happiness about commuting convenience as an example to quantify this variation. To begin with I present a simple plot of the whole sampled homeowners' median happiness value before-against-after the transport improvement, within 2km of a new station (see Figure 2). The triangle-dots are those new stations at the central city, and star-dots are new stations at the suburb. The solid line is the 45 degree line. In Figure 3, I use the vertical deviation of each dot in Figure 3.2 from the 45 degree line to visualise the spatial variation of the median happiness changes at each new station area[21]. Perhaps surprisingly, most of new station areas---primarily at the suburb, lie well above the 45 degree line implying that they are relative high happiness improvement areas. In contrast, some central new stations lie slightly below the 45 degree line implying that they are relative negative happiness improvement places. One possible explanation is that homeowners living in the station areas of the central city may have experienced less distance reductions to new stations than those who live in the suburb station areas. This could also be explained by the dilemma between the heavy transport demand in the central city and inadequate rail transit capacities and frequencies during the rush-hours.

The visualization of happiness changes shown in the above figures[22] is essentially the complimentary descriptions for the table results. One should not read too much into these tables and figures at this stage because I have not examined whether the differences in key observable pre-treatment characteristics of treated and control areas are statistically significant. For the most part, a *t*-test in the mean difference between column (3) and column (5) shows no obvious differences at the 5%

[21] See appendix B for the full results.
[22] I have also investigated the median happiness changes relative to commuting convenience by using the 1 km and 4 km distance bands. The results mirror the patterns of the 2km distance band results (see appendix D).

significance level[23]. The only two imperfect variables on which the treated and control places do not appear to be well balanced are indicators about station-distance and happiness about traffic safety. For example, station-distance is relatively lower and happiness about traffic safety is relatively higher in the treatment group. One potential concern about the imperfect balancing is if the place-based transport investment and consequent rail access differentials, encourage sorting of households for places with higher happiness about traffic safety. In this sense, it is likely that I might do better in terms of control-treatment balancing by considering a restricted sub-sample of non-market housing homeowners whose pre-determined residential locations can be regarded as exogenous. I test this in Table 2, which uses the same treatment selection principles but focus typically on non-market housing homeowners. Doing this does bring improvements in the treatment-control balancing conditions, where a *t*-test of the differences in mean between column (3) and column (5) shows no differences at the 5% significance level. Importantly, it does not make significant difference to the main results, showing that these descriptive statistics are not sensitive to the sample choice. In Figures 4-5 I move to non-market housing sample but apply the same method described in Figures 2-3. Again I see the general result patterns are reassuringly robust to this sample change, though fewer new stations lie below the 45-degree line. In any case, I will test formally the impact of rail access changes on homeowners' happiness using the model specified in the following section.

4 Model

Using the survey data, I examine what happens to homeowners' happiness before and after the transport infrastructure changes. Then, by observing what happens in

[23] Note that repeating this exercise for either 2km or zone-level cell unit cluster sizes, tends to improve the balancing conditions in terms of pre-treatment characteristics, but I report the "worst scenario" so that readers can judge for themselves the scientific reliability of the results.

"treated" versus "control" places, I can more reliably assess the effects from rail access changes on happiness.

The starting point for my analysis is a basic regression model[24] relating homeowners' happiness to rail access---measured by the nearest distance to the station:

$$LnHappy_{it} = \alpha + \beta \cdot dist_{it} + \delta \cdot \ln(income_{it}) + \theta \cdot X'_{it} + f_i + g_t + \varepsilon_{it} \quad (1)$$

$Happy_{it}$ in Eq. (1) is the average happiness of a particular residential aspect (commuting convenience, traffic safety, social environment, living convenience and traffic pollution) in cell unit i in period t, $dist_{it}$ is the nearest-station distance, $income_{it}$ is the sampled households' average monthly income[25], X_{it} is a vector of other household and location characteristics (see variable definitions in the appendix table 3.3), f_i represents place-specific fixed effects, and g_t indicates a time effect that would better capture changes in happiness over time (that are not accounted for by changes observable characteristics).

This model specification can be easily generalized. For example, I would expect a 100 meter distance reduction to stations within 2 km distance ball to be much more highly valued than a 100 meter reduction at 20 km distance. My empirical model specifications allow for such differences between place of residences that are within 2 km of a station and place of residences that are beyond 2 km from the nearest station. Defining $r_{it} = I\{\mathrm{dist}_{\mathrm{it}} \leq 2\mathrm{km}\}$ an indicator that distance is less than 2 km, then I can have:

$$LnHappy_{it} = \alpha + \beta_1 \cdot r_{it} dist_{it} + \beta_2 \cdot (1 - r_{it}) dist_{it} + \delta \cdot \ln(income_{it}) + \theta \cdot X'_{it} + f_i + g_t + \varepsilon_{it} \; (2)$$

---

[24] Searching over a number of choices of the functional forms it was determined that a function with the log transformation provided the best fit to the data.
[25] For the evaluation in monetary terms, estimates for the marginal utility of household income need to be considered.

Estimation of a model specification like Eq.(1) and (2) can provide estimates of happiness for a wide range of determinants associated with the location of a homeowner's place of residence. However, some factors may have indirect effects on homeowners' happiness for reasons other than the benefits of increased rail access. For instance, stations may be located in street corners that offer fancy pubs, retail outlets, churches and other local amenities that might bring additional residential happiness for households.

To account for these factors, one can always control for as many as local characteristics in the regressions. But some factors like air quality cannot be observed easily. As such, the model in (1) and (2) assumes that unobserved factors are fixed over time (f_i). However, the estimation results are still likely to be biased if these unobserved attributes are correlated with the station-distance variable. The difference-in-difference strategy based on time differences would eliminate pre-existing location characteristics and provide more reliable estimates on the net happiness effects of the transport improvement program. The final underlying model becomes:

$$\begin{aligned}(LnHappy_1 - LnHappy_0) = (g_1 - g_0) + \beta_1 \cdot r_{i1}(dist_1 - dist_0) + \beta_2 \cdot (1 - r_{i1})(dist_1 - dist_0) \\ + \delta \cdot \left[\ln(income_{i1}) - \ln(income_{i0})\right] + \theta \cdot (X_{i1} - X_{i0})' + (\varepsilon_{i1} - \varepsilon_{i0})\end{aligned} \quad (3)$$

I estimate this model using micro data on individual respondents, aggregated to cell-unit-period level. The two time periods are post-transport improvement (t =1) if year=2009, and pre-transport improvement (t =0) if year=2005. Since I have only two survey samples, the parameters β_1 and β_2 therefore provide difference-in-difference estimates for the impact of rail access changes on homeowners' happiness at affected places before and after the building of new rail transit lines. In the result section, regression estimates are measured by the specification form in Eq. (3).

There are at least three limitations to the models presented above. The first limitation is the common time-trend assumption. In general, one would expect observed and unobserved characteristics to be evolved with the transport improvement. My results might therefore underestimate the rail access effect if homeowners' happiness adjustment process is long before or after the building of new subway lines, or might overestimate the amenity benefits if other local externalities at station areas evolve with the increased rail access. This problem is not unique here. Ideally, one could control for a number of things (i.e. crime, shops, cafes, travel time) change together as a result of the stations opening if those detailed data is accessible. However, to the best of my knowledge, there are no publicly available data sources in which I can merge systemic information on localized changes with detailed data on residents' happiness and characteristics. When one is reading the results, it is important to keep in mind that the cell-unit level happiness measures might capture the additional impact of variation at the local areas. Practically, I do check the resulting estimates by using different data sample to make sure that they appeared reasonable. I also conduct the analysis disaggregated by households' income and age[26]. As such I can better capture the heterogeneous effects from rail access changes on happiness across different social groups.

Secondly, empirical studies like this have often faced the difficulty of the joint choice of transportation modes and residential locations. Households who live near rail stations may be more likely to travel by rail transits. But there are several explanations underlying this observed correlation. On the one hand, better rail access is expected to encourage residents who were not public transport users to commute by rail transits now. To this end, I control for the proportions of public transport users in

[26] I use the sampled residents' median income and median age as the cut off points to create four social groups, and I find that there are no significant happiness variations within each group. However, I recognize that this classification method is not the only way to group households' characteristics. Other household characteristics would also contribute to the differences of people's happiness evaluations.

every cell unit before and after the transport improvement. On the other hand, households who prefer this transit mode will choose to live near rail stations. To address this issue, I focus solely on the homeowners ("stayers") who have already lived in the current residences for at least five years---that is, the period before the new rail transit constructions. Since my data is a panel of areas, I also test for potentially endogenous changes to the compositions of residents in response to transport improvements. Specifically, I have examined changes in the composition of residents in affected places but found little evidence by comparing the cell unit composition of 2005 sampled homeowners and 2009 sampled homeowners, and by comparing the composition of those in the locations with greatest accessibility improvements who had recently moved-in with those living there more than 5 years. Finally, I take advantage of policy-exogeneity nature of non-market (*fang gai*) housing with pre-determined locations as an additional robustness check. Below, I will run the regressions for the whole sampled homeowners first, and then for the non-market (*fang gai*) housing sampled homeowners.

A further potential source of bias may arise from the conducted timing of the surveys. It is worth noting that in 2005 when the new metro lines and stations were being constructed, accessibility for residents at station areas might be in fact lowered by localized congestion---which could lead to lower residents' happiness level in 2005 survey. When new stations were opened, the changes in their happiness levels would reflect not just the commuting time savings, but also the disappearance of the noise or congestion effects at the station areas. Despite these limitations, I believe that difference-in-difference modeling the happiness effects of transport improvements is an important step in evaluating the place-based government investment program.

5 Results

The rail access changes induced by the building of new rail transit lines allow me to estimate how homeowners' happiness with respect to several dimensions of residential environment changes for places experiencing station-distance reductions to within 2km. In Tables 3-7, I report regression estimates of the model in Eq. (3) using the cell unit panels, both for the whole sample and for the non-market housing subsample. The only variation in residence-station distance is before and after the building of new stations in 2008, in places affected by the rail access changes. Thus any measured effects of the transport improvement program on happiness occur through station distance changes due to the building of new rail transit lines.

5.1 Baseline estimates

Columns (1)-(2) in Table 3 are for the whole sample. Column (1) shows estimates that allow for household income and other characteristics, as well as cell unit fixed effects. Happiness about commuting convenience is found to rise in treated places by around 6.18% (=100*[exp (0.060)-1]), on average, for every kilometre reduction in distance close to the stations (within 2 km)[27]. There is no statistically significant impact from distance reductions to places that are beyond 2 km from the new stations.

Part of the increased rail access effect could be attributable to local contextual effects. One reason to do this is that, for the time period I study, new subway lines are likely to extend into the 2008 Olympic Park area and important "bedroom" communities (*Tiantongyuan*, *Yizhuang*, *Tongzhou*, *Daxing*). Thus I control for a long list of location characteristics such as the distance to CBD, Olympic Park, bedroom

[27] It is noteworthy that happiness changes would rise more than proportionately with station proximities. As shown in Table 7, there is a bit of a non-linear happiness elasticity effect going from those within 4kms to those within 1km of a station.

areas, etc (documented in appendix C). The main result is robust to this model specification, showing that better rail access can lead to the higher levels of happiness about commuting convenience. One thing to note is that, in the specifications from columns (1) to (2), I also find that homeowners' happiness about commuting convenience, though not statistically significant, rise slightly with distance reductions in the "control" group (places that is beyond the 2 km distance band). This result suggests that the impact of new stations on homeowners' happiness about commuting convenience is higher closer in.

Switching to the sample for non-market (*fang gai*) housing homeowners in columns (3)-(4), I find the same qualitative pattern, though the increased rail access effect are estimated to be larger than that in the whole sample. After controlling for all the characteristics in column (4), there is a 9.19% (=100*[exp(0.088)-1]) happiness rise per kilometre distance reduction to stations. Importantly, this result confirm the possibility that the rail access impact on homeowners' happiness largely holds after considering for the potential endogeneity in residential locations by using the non-market (*fang gai*) housing subsample.

Continuing to discuss about the rail access impact on happiness of commuting convenience, I next break down such impact by using four social groups: high income*high age, high income*low age, low income*high age, low income*low age. This comparison highlights the significant heterogeneity happiness effects across different social groups. Estimates in columns (1) and (6) of Table 6 show that, for homeowners in the high-income groups, the happiness effect relative to commuting convenience is about two times higher than the average, whilst such effect is very small for the low-income groups. I also find that young residents gain more happiness than elderly people when treated with new stations. The results are robust across the whole sample and the non-market housing sample. This is consistent with the expectations that high-income and low-age residents who attach great value to their works, are likely to be much happier about the commuting time savings provided by the improved transport accessibility.

Table 4 reports the results of the impact of increased rail access on homeowners' happiness about traffic safety. In the whole sample specifications (columns 1-2), homeowners' traffic safety happiness significantly decrease with the distance reductions to stations. Specifications (columns 3-4) of the non-market housing sample share the same pattern of results. This result implies that the increased rail access may alter the distribution of traffic safety happiness around the station areas by increasing the local residents' safety concerns.

Comparing the coefficients on different social groups (documented in columns (2) and (7) of Table 6) provides estimates of the bias associated with the sample mean results in Table 4. Estimates from the high income*high-age group show the highest traffic safety happiness declination when treated with new stations. This is expected because the higher opportunity costs of safety issues at the station areas may enhance high-income residents' dissatisfaction about the rail transit expansions. Perhaps interestingly, I also find that the increased rail access impact does not significantly influence the traffic safety happiness for the low age*low income group.

In Table 5, I find that the presence of the new stations slightly improves homeowners' happiness about living convenience and traffic pollution in places that received effective distance reductions to stations. However, homeowners become less happy about social environment when their residences are treated with new stations. This tells a consistent story with actual observations in Beijing, where the original homeowners are not satisfied about the growing population flows and noise at the station areas. In the specifications linked with different social groups (Table 6), high-income groups show significant improvements in their happiness levels of living convenience and traffic pollution, but they become less happy about local social environment when treated with new stations. In the low-income groups, there are no strong evidence of better rail access effects on their happiness of living convenience, social environment and traffic pollution.

My purpose here is twofold: my first purpose is to shed light on what is known and unknown about homeowners' happiness with respect to different residential dimensions that may be affected by the transport improvement program. My results suggest that rail access effects on the various happiness dimensions of residential environment might tend to offset each other. Using the overall life happiness indicator would therefore mask the interpretations about the impact of the transport improvement program at particular residential aspects of households' living experiences. Second, I clarify the importance of considering the heterogeneous happiness effects on different social groups. For a more accurate assessment, I conduct the Chow test (Chow, 1960) to examine whether the key coefficients in each of the two regressions on different social group data sets are equal. This means that, for each of the happiness indicator, I use the Chow test to examine whether the coefficient of station-distance reductions (within 2km) in one specific social group is statistically equal to that in another social group. Perhaps surprisingly, I find that the null hypotheses are rejected at the 5% significance level, suggesting that the observed differences in the effects from rail access changes on happiness for different social groups are statistically significant. To the extent that this type of exercise is a significant tool informing this argument, my results show that the amenity benefits of rail access are highly dependent on residents' background characteristics. Which social group should be the “most representative”? This is certainly debatable. But clearly, beyond income-and-age groups presented in this study, there should be a long list of individual characteristics like education attainment, occupation that would further disaggregate residents into a large number of social groups. Researchers estimating the benefits of transport improvement program should take care to consider social differentiations at a reasonable geographical scale.

5.2 Sensitivity analyses

Tables 7 shows various sensitivity analyses for the baseline results presented in Tables 3-5. The first test focuses on whether my conclusions are sensitive to issues regarding the distance band selections. This test would hold everything the same in the model specification and any changes in rail access effects would attribute to the difference in the valuation of distance bands. In Table 7, estimates from the specification A overviews the baseline estimates. Specifications B-C show estimates for the variations in how I define the distance bands. The rationale behind this is that, homeowners’ happiness would change more than proportionately with station proximity. Recall that the hedonic studies tend to have found capitalization effects of rail stations is localized with a strong distance decay effect (see Cheshire and Sheppard, 1995; Bowes and Ihlanfeldt, 2001). First, I use a 1km distance band instead of the previous 2 km distance band. This modification results in little changes, with stronger evidence of positive happiness effects associated with commuting convenience. This is in line with my prior expectations that the substantial increase in happiness about commuting convenience with better accessibility of those living near the new stations. This may also be partly due to the disappearance of negative construction impacts at the very localized station areas. Second, I revert to the 4km distance band. While the commuting and living convenience happiness effects are generally robust, happiness effects relative to other residential aspects turn to be insignificant. This implies that a 2-kilometre ball around the station is suitable for defining the happiness impacts of improvements in rail access at station areas---not at remote places[28].

Because the Beijing urbanized area is very large, it may have a substantial impact on the baseline estimates. I therefore, in the specification D, report results based on the 2km distance band but excluding the central city sample[29]. For the specification with the suburb sample, there is more sizable positive association between rail access and sub-urbanites' happiness about commuting convenience. There are several explanations for this: on the one hand, it is likely that the discomfort station facilities, insufficient capacities and frequencies of new rail transits may reduce the happiness improvement about commuting convenience for central city homeowners; on the other hand, it is well understood that suburbanites, faced with long commuting distance to work, are more easier to gain happiness towards commuting convenience due to the building of new rail transit lines. I also find slightly higher negative traffic safety happiness outcomes compared to the baseline results. This is possibly because of the high crime rates in the suburb areas. The happiness results relating to other residential aspects are similar to the baseline estimates.

Finally, I consider another issue related to different commuting modes. Recall that the baseline results are estimated by the sampled homeowners no matter whether they commute to work by using public transportation or not. In the specification E, I have restricted the attention to the public commuters sample only. I examine whether

[28] Note that homeowners who resided more than 4 km away from a new station might also benefit from the improvements in rail access and would be far enough from the localized congestion nuisances at the station areas. I have tested this hypothesis and find no evidence to support this claim.

[29] Following the convention, the central city is defined as the areas within the No.3 ring road of Beijing.

and to what extent the impact of station distance reduction (to within 2km) affects the happiness outcomes on public transport users. The results show the same qualitative nature as the baseline estimates with respect to all happiness indicators. In terms of quantitative differences, I find that public commuters have gained are more significant and sizable happiness improvements with respect to commuting and living convenience than all commuters. This is expected because public transport users are more likely to get direct time savings with better access to stations. And although not shown in the table, the estimated coefficients between public commuters and all commuters are statistically different from each other.

6 Monetization

One of the primary goals of the transport improvement program in Beijing is to upgrade households' living experience with respect to different dimensions of residential environment. In this section, the monetised welfare effect of implementing the transport improvement program is measured by the compensating variation (CV). That is, I examine the homeowners' average willingness-to-pay at the aggregated cell unit level for changes in rail access at their residence, holding housing prices and other local attributes constant[30]. For a transport policy which leads to rail access changes from $dist_{i0}$ to $dist_{i1}$ the CV estimate can be implicitly defined as:

$$F_i\left(income_{i0}; dist_{i0}\right) = F_i\left(income_{i1} - CV; dist_{i1}\right) \qquad (4)$$

Where $F(*)$ represents the indirect utility function. The subscript zero denotes originally household income and station-distance attributes at cell-unit i, whereas the subscript one indicates these attributes at cell-unit i after the transport improvement

[30] Note that I also assume that the housing supply is constant. This implies that the computed welfare estimates are essentially partial equilibrium measures. Given the data limits, I find little evidence of general equilibrium happiness effects from the transport improvements in Beijing. Thus this study does not attempt to identify general equilibrium benefit measures that account for anticipated housing price effects. See detailed comparisons between partial and general equilibrium welfare measures in Sieg et al. (2004) and Tra (2010), among others.

program. With the estimated coefficients of the econometric happiness equation (3) for changes in rail access (β_1), and income (δ), the CV can be calculated as follows:

$$CV = income_1 - e^{\frac{\beta_1 \cdot (rail\_access_0 - rail\_access_1) + \delta \ln(income_0)}{\delta}} \qquad (5)$$

In light of recent literature, this CV welfare measure implicitly assumes that public investment programs do not immediately affect housing prices in the urbanized area (Takeuchi et al, 2008; Frey et al, 2009). Hence, this CV welfare measure could be interpreted as the monetary benefits of the transport improvement program over and above housing costs. Since the CV calculation also holds the housing supply fixed, my results therefore only reflect the benefits of the transport improvement program in the short run.

Table 8 reports the mean welfare effects of the improvements in rail access on homeowners' different happiness aspects. All CV estimates are measured on the basis of cell unit aggregated data, before-and-after the building of new subway lines in 2008. In terms of happiness about commuting convenience, I find that the improvements in rail access are worth, on average, about CNY 1,136 (approximately 100 GBP) per month to the whole sampled homeowners in Beijing. This means that the welfare benefit represents roughly 17.3 percent of the monthly average income of a sampled Beijing homeowner. The happiness results for living convenience and traffic pollution show that the average sampled homeowners would be willing to pay around 9.5% and 6.6% respectively of their monthly income for the distance reduction to stations. The mean welfare measure is CNY-489 per month for the happiness about traffic safety, compared to an average benefit of CNY-378 per month for the happiness about social environment. In general, these welfare estimates are robust across the whole sample and the non-market housing sample homeowners.

Interestingly, I also find that the benefits of the transport improvements vary considerably across income groups. For example, the mean welfare measure relative to happiness of commuting convenience is about CNY 716 per month for the 20th income percentile homeowners, compared to a mean monthly benefit of CNY 1,828 for the 80th income percentile homeowners. In addition, the effects of increased rail access are not distributed evenly across the urban space. For example, the welfare results for happiness about commuting and living convenience show that suburb homeowners experience, on average, relative higher welfare gains compared to homeowners living in the central city. However, central city homeowners experience higher benefits relating to happiness about traffic pollution than suburb homeowners under the transport improvement program. Such variations among urbanites and suburbanites are also obvious in term of social environment and traffic safety happiness.

I do not want to over-emphasize these findings, however, as there are some problems underlying this happiness valuation approach. One relates to the survey-reported income. Most of surveys employed in happiness studies provide implicit information on income. For example, the micro survey data applied in this study only recorded households' income in categorical terms rather than actual income money figures. Thus this measurement would lead to imprecise the estimated welfare measures. Another issue is that the causes and consequences of household income changes will vary across places and in some situations might vary systemically within a certain place (Clark and Oswald, 1996; Frijters et al., 2004; Ferrer-i-Carbonell, 2005). Indeed it is highly possible that the rising income itself would provide additional life enjoyment in all residential aspects. This makes the valuation of happiness consequences of exogenous income adjustments an interesting topic in the economic literature that I leave to future research. Further, I am well aware that there is a detailed discussion in the happiness literature about the reverse causation (happy people are less unemployed and earn more) and unobserved factors (there may be no link between happiness and income---it's all driven by resilience and non-cognitive abilities). However, this paper cannot fully explore these effects without long-run surveys and more detailed census data. Finally, the estimated welfare benefits here are measured by using the aggregated cell-unit data. Thus the resulting monetary estimates are likely to be biased and would conceal variations among individuals. I note, however, that most of these issues can be addressed when better data become available; and they do not fully invalid the happiness valuation approach. Despite of these limitations, this monetization analysis is still a useful exercise that could shed light on potential welfare benefits of the transport improvement program.

7 Conclusions

In this paper I consider links between rail access and homeowners' happiness, providing new evidence that better rail access does affect homeowners' happiness with respect to different dimensions of residential environment. I implement the difference-in-difference model based a recent transport infrastructure change in Beijing. The change I consider referred to the building of new stations, so I can use repeated survey data to examine what happened to homeowners' happiness in particular residential aspects when residence-station distances were reduced.

My results yield three important insights. First, I find that homeowners' happiness about commuting convenience rise significantly in places affected by the building of new stations, relative to places that were unaffected. I also find that homeowners' residences receiving increased station proximities experience improvements in happiness about traffic pollution and living convenience. On the flip side, the impacts of station-distance reductions are found to decrease the homeowners' happiness towards traffic safety and social environment nearby station areas. These results pass through a series of sensitivity tests and remain robust in terms of qualitative nature.

Second, the effect of rail access changes on happiness depends on geographical locations and socioeconomic characteristics. Broadly speaking, suburbanites gain greater happiness about commuting convenience than urbanites when their places of residences experienced distance reductions to new stations. High-income homeowners in areas affected by the transport improvement place substantial happiness value on commuting convenience and other residential aspects, whilst low-income homeowners do not appear to value the increased rail access highly. These findings are robust after controlling for the potential endogeneity in residential locations by using the non-market (*fang gai*) housing sample. One important implication here is that researchers estimating the rail access effects should take care to do data mining and empirical specifications that allow the inclusion of targeted social groups over urban areas.

Third, the welfare evaluation results suggest that Beijing homeowners place substantial value on improvements in the rail access. I estimate the average willing-to-pay by homeowners for the improvement in the rail access at their residence, holding housing prices and other location factors constant. I find that the welfare benefits vary considerably relative to different happiness aspects, income groups and urban areas. All of these pieces of evidence support the claim that planners and policymakers need to consider social-spatial differentiations when evaluating the happiness consequences of government investment in local infrastructure.

In considering the happiness consequences brought about by transport improvements, it is important to note that I have only examined the direct effects from rail access changes on homeowners' happiness with respect to different dimensions of residential environment. There is considerably debate with respect to the inter-connected reflections on changes in happiness, housing price capitalization, and self-selection. More evidence is needed to strengthen our knowledge of the interrelationship between changes in happiness and expected changes in housing prices, and how would such changes affect homeowners' decision to stay or move.

My future work in this line of research would include several pieces. First, I expect to obtain more detailed income and systemic housing transaction data in the appropriate years and locations. Indeed, it would be really interesting not just to back out the "value" of happiness via the sample incomes but to directly relate the happiness measures to the hedonic estimation of capitalization effects. Presumably the changes in happiness are reflected in changes in effective housing demands so in some way capitalized into housing prices. Second, I would link the real estate consequences directly to my findings on the distribution of changes in happiness for high income/young compared to low income/old resident group, using detailed residential mobility information at the individual level. Specifically, I will test the extent to which the changes in happiness are linked to changes in housing prices and in turn linked to differential residential mobility with an inflow of those most benefiting in happiness terms from the improvements in transport accessibility. In so far as this occurred then there would be policy implications for neighbourhood dynamics and also for the long-term impact on the social welfare. Even those who do not value the transport improvements would be compensated if property owners have experienced price premiums and have the ability to turn that into money if they move to an area where accessibility has not improved. Given that they appear to value good access less than young/high wage then their welfare would be improved by trading more money for less transport accessibility. The third piece of my future work hopes to learn more about the self-selection and anticipation effects of transport improvements. I clarify the importance of considering the interrelationship between changes in happiness and neighbourhood demographic dynamics as a result of transport improvement. It is interesting to know: Is there a change in the composition of residents in locations benefiting most from the transport improvements with a differential increase in the representative groups rating the transport improvements highly in terms of happiness? Future happiness studies using long-run survey data in different contexts to corroborate the robustness of my findings would be useful.

References

Adriaanse, C. C. M., 2007. Measuring residential satisfaction: a residential environmental satisfaction scale. Journal of Housing and Built Environment 22, 287–304.

Alesina, A., Di Tella, R., MacCulloch, R., 2004. Inequality and Happiness: are Europeans and Americans Different?. Journal of Public Economics 88, 2009–2042.

Aragonés, J.I., Francescato, G., Gärling, T., 2002. Evaluating residential environments. In: Aragonés, J.I., Francescato, G., Gärling, T. (Eds.), Residential Environments: Choice, Satisfaction, and Behavior. Bergin and Garvey, Westport, CT.

Blanchflower, D., Oswald, A., 2004. Wellbeing over time in Britain and the USA. Journal of Public Economics 88, 1359–1386.

Bowes, D., Ihlanfeldt, K., 2001. Identifying the impacts of rail transit stations on residential property values. Journal of Urban Economics 50, 1–25.

Campbell, A., Converse, P. E., Rodgers, W. L. 1976. The Quality of American Life: Perceptions, Evaluations and Satisfactions. New York: Russell Sage.

Cheshire, P.C., Sheppard, S. 1995. On the Price of Land and the Value of Amenities. Economica 62, 247–267.

Clark, A., Oswald, A., 1996. Satisfaction and Comparison Income. Journal of Public Economics 61, 359–381.

Cornaglia, F., Leigh, A., 2011. Crime and Mental Wellbeing. CEP Discussion Papers, No.1049. Centre for Economic Performance (CEP), London School of Economics and Political Sciences, London, UK.

Di Tella, R., MacCulloch, R., Oswald, A., 2001. Preferences over Inflation and Unemployment: Evidence from Surveys of Happiness. American Economic Review 91, 335–341.

Dowall, D.E., 1994. Urban Residential Redevelopment in the People's Republic of China. Urban Studies 31, 1497–1516.

Ferrer-i-Carbonell, A., 2005. Income and well-being: an empirical analysis of the comparison income effect. Journal of Public Economics 89, 997–1019.

Freeman, A.M.III., 2003. The Measurement of Environmental and Resource Values: Theory and Methods. Washington, D.C.: Resources for the Future.

Frey, B., 2008. Happiness: A Revolution in Economics. Cambridge, MA and London: MIT Press.

Frey, B., Luechinger, S., Stutzer, A., 2009. The life satisfaction approach to the value of public goods: the case of terrorism. Public Choice 138, 317–345.

Frey, B., Stutzer, A., 2001. What Can Economists Learn from Happiness Research?. Journal of Economic Literature 40, 402–435.

Fu, Y.M., Tse, D.K., Zhou, N., 2000. Housing Choice Behavior of Urban Workers in China's Transition to a Housing Market, Journal of Urban Economics 47, 61–87.

Gibbons, S., Machin, S., 2005. Valuing rail access using transport innovations. Journal of Urban Economics 57, 148–169.

Gibbons, S., Machin, S., 2008. Valuing School Quality, Better Transport and Lower Crime: Evidence from house prices. Oxford Review of Economic Policy 4, 99–119.

Gibbons, S., Silva, O., 2011. School Quality, Child Wellbeing and Parents' Satisfaction. Economics of Education Review 30, 312–331.

Huang, Y., Clark, W.A.V., 2002. Housing tenure choice in transitional urban China: a multilevel analysis. Urban Studies 39, 7–32.

Kahneman, D., Krueger, A.B., 2006. Developments in the Measurement of Subjective Well-Being. Journal of Economic Perspectives 20, 3–24.

Kahneman, D., Krueger, A.B., Schkade, D., etc, 2006. Would You Be Happier If You Were Richer? A Focusing Illusion. Science 312, 1908–1910.

Kearney, A.R., 2006. Residential development patterns and neighborhood satisfaction: impacts of density and nearby nature. Environment and Behavior 38, 112–139.

Krueger A., Schkade, D., 2007. The Reliability of Subjective Wellbeing Measures. NBER Working Paper No. 13027.

Layard, R., 2005. Happiness: Lessons from a New Science. London: Penguin Press.

Lu, M., 1999. Do people move when they say they will? Inconsistencies in individual migration behavior. Population and Environment 20, 467–488.

Luechinger, S., 2009. Valuing air quality using the life satisfaction approach. Economic Journal 119, 482–515.

Mohan, J., Twigg, L., 2007. Sense of place, quality of life and local socioeconomic context: evidence from the survey of English housing, 2002/03. Urban Studies 44, 2029–2045.

Oswald, A., Wu, S., 2010. Objective Confirmation of Subjective Measures of Human Well-Being: Evidence from the U.S.A. Science 327, 576–579.

Parkes, A., Kearns, A., Atkinson, R. 2002. What makes people dissatisfied with their neighbourhoods?. Urban Studies 39, 2413–2438.

Permentier M., Bolt G., Ham, M. van., 2011. Determinants of neighbourhood satisfaction and perception of neighbourhood reputation. Urban Studies 48, 977–996.

Sato, H., 2006. Housing inequality and housing poverty in urban China in the late 1990s. China Economic Review 17, 37–50.

Sieg, H., V. K. Smith, H. S. Banzhaf, and R. Walsh. 2004. Estimating the General Equilibrium Benefits of Large Changes in Spatially Delineated Public Goods. International Economic Review 45(4), 1047-77.

Takeuchi, A., Cropper, M., Bento, A., 2008. Measuring the Welfare Effects of Slum Improvement Programs: The Case of Mumbai. Journal of Urban Economics 64, 65–84.

Tra, C. 2010. A discrete choice equilibrium approach to valuing large environmental changes. Journal of Public Economics 94(1-2), 183-196.

Wu, W.J. 2012. Does Public Investment Spur the Land Market?: Evidence from transport improvement in Beijing. SERC Discussion Papers, No.00116, Spatial Economics Research Centre (SERC), London School of Economics and Political Sciences, London, UK.

Wu, W.J., Zhang, W.Z. and Dong, G.P. 2013. Determinant of residential location choice in a transitional housing market: Evidence based on micro survey from Beijing. Habitat International, 39, 16–24.

Zhang, W.Z., Yin, W., Zhang, J., etc., 2006. A Study of Livable Cities in China (Beijing). Beijing: Social Sciences Academic Press (China).

Zheng, S.Q., Kahn, M.E., 2008. Land and residential property markets in a booming economy: New evidence from Beijing. Journal of Urban Economics 63, 743–757.

Table list

Table 1 Descriptive statistics of rail access and happiness: the whole sample

	Full sample		Treatments		Controls		Estimates
	Before	After	Before	After	Before	After	Raw
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Station Distance	1.871	1.173	1.720	0.513	1.931†	1.399	-1.015*
	(0.610)	(0.621)	(0.372)	(0.236)	(0.682)	(0.655)	(0.571)
Ln (Commuting convenience)	1.423	1.476	1.451	1.526	1.413	1.460	0.064**
	(0.171)	(0.179)	(0.120)	(0.142)	(0.186)	(0.187)	(0.033)
Ln (Traffic safety)	1.428	1.408	1.446	1.418	1.421†	1.405	-0.056**
	(0.182)	(0.175)	(0.145)	(0.152)	(0.194)	(0.181)	(0.028)
Ln (Social environment)	1.533	1.504	1.548	1.513	1.527	1.501	-0.043*
	(0.192)	(0.178)	(0.182)	(0.117)	(0.196)	(0.192)	(0.025)
Ln (Traffic pollution)	1.360	1.388	1.372	1.393	1.355	1.386	0.031*
	(0.211)	(0.216)	(0.213)	(0.164)	(0.211)	(0.226)	(0.018)
Ln (Living convenience)	1.443	1.475	1.461	1.521	1.437	1.460	0.044**
	(0.163)	(0.165)	(0.131)	(0.143)	(0.173)	(0.172)	(0.021)
Sample size	883	750	252	191	631	559	1633

Notes.--- The whole sample refers to the sampled homeowners who work and hold the tenure before the transport improvement happened. Treatment refers to cell units for which distance to rail station was less in year 2009 than in 2005, and where distance in year 2009 was less than 2 km. Data units are before/after cell units. Columns (1)-(6) show means and standard deviations (in parentheses). Column (7) shows the simple difference-in-difference estimated coefficients based on the raw data (Standard errors corrected for clustering at the cell unit level are reported in parentheses). † denotes that the control group is significantly different from the treatment group in terms of the pre-treatment characteristic at the 5% level. *** p<0.01, ** p<0.05, * p<0.1.

Table 2 Descriptive statistics of rail access and happiness: non-market housing sample

	Full sample		Treatments		Controls		Estimates
	Before	After	Before	After	Before	After	Raw
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Station Distance	1.601	1.142	1.569	0.420	1.611	1.363	-0.991**
	(0.584)	(0.595)	(0.361)	(0.238)	(0.652)	(0.630)	(0.386)
Ln (Commuting convenience)	1.446	1.488	1.451	1.556	1.443	1.468	0.108**
	(0.171)	(0.212)	(0.115)	(0.166)	(0.187)	(0.223)	(0.051)
Ln (Traffic safety)	1.463	1.430	1.469	1.428	1.460	1.431	-0.052**
	(0.192)	(0.206)	(0.155)	(0.150)	(0.202)	(0.217)	(0.026)
Ln (Social environment)	1.540	1.516	1.543	1.501	1.538	1.520	-0.051*
	(0.185)	(0.207)	(0.183)	(0.183)	(0.187)	(0.213)	(0.029)
Ln (Traffic pollution)	1.369	1.388	1.362	1.398	1.371	1.385	0.045**
	(0.225)	(0.253)	(0.221)	(0.228)	(0.227)	(0.260)	(0.023)
Ln (Living convenience)	1.445	1.489	1.468	1.533	1.435	1.476	0.048**
	(0.166)	(0.192)	(0.135)	(0.148)	(0.175)	(0.211)	(0.021)
Sample size	751	587	235	137	516	450	1338

Notes.---The non-market housing sample refers to the sampled homeowners who work and hold the tenure of the non-market (*fang gai*)housings before the transport improvement happened. The estimation accounts for the endogeneity residential sorting by using this non-market housing sub-sample with pre-determined residential locations. Treatment refers to cell units for which distance to rail station was less in year 2009 than in 2005, and where distance in year 2009 was less than 2 km. Data units are before/after cell units. Columns (1)-(6) show means and standard deviations (in parentheses). Column (7) shows the simple difference-in-difference estimated coefficients based on the raw data (Standard errors corrected for clustering at the cell unit level are reported in parentheses). The *t*-test in mean difference between columns (3) and (5) shows no differences at the 5% level. *** p<0.01, ** p<0.05, * p<0.1.

Table 3 Rail access and homeowners' happiness of commuting convenience

	(1)	(2)	(3)	(4)
	The whole sample		Non-market housing sample	
Rail access				
station distance <2km	-0.060**	-0.051**	-0.105**	-0.088**
	(0.029)	(0.026)	(0.046)	(0.040)
station distance >2km	-0.035	-0.028	-0.051	-0.039
	(0.062)	(0.046)	(0.045)	(0.032)
Household income	Yes	Yes	Yes	Yes
Other household characteristics	Yes	Yes	Yes	Yes
Time effect	Yes	Yes	Yes	Yes
Location characteristics	No	Yes	No	Yes
Within R^2	0.426	0.445	0.567	0.581
Sample size	1633	1633	1338	1338
Fixed effects variance share	0.693	0.686	0.733	0.725

Notes.---Dependent variable is log happiness of commuting convenience. Columns (1)-(2) is estimated using the whole sampled residents. Columns (3)-(4) is estimated based on the non-market housing sample. The whole sample refers to the sampled homeowners who work and hold the tenure before the transport improvement happened. The non-market housing sample means the long-term tenure homeowners who work and lived in non-market (*fang gai*) housings with pre-determined locations. Data is aggregated to cell unit level for two snapshots: 2005 and 2009. Regressions include control variables detailed in appendix E table. The constant term is omitted for simplicity but available from the author on request. Standard errors corrected for clustering at the cell unit level are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 4 Rail access and homeowners' happiness of traffic safety

	(1)	(2)	(3)	(4)
	The whole sample		Non-market housing sample	
Rail access				
station distance <2km	0.053**	0.046*	0.048**	0.038**
	(0.026)	(0.023)	(0.021)	(0.018)
station distance >2km	0.031	0.025	0.026	0.019**
	(0.022)	(0.018)	(0.023)	(0.011)
Household income	Yes	Yes	Yes	Yes
Other household characteristics	Yes	Yes	Yes	Yes
Time effect	Yes	Yes	Yes	Yes
Location characteristics	No	Yes	No	Yes
Within R^2	0.413	0.419	0.523	0.526
Sample size	1633	1633	1338	1338
Fixed effects variance share	0.651	0.645	0.693	0.685

Notes.---Dependent variable is log happiness of traffic safety. See other notes in table 3.

Table 5 Rail access and homeowners' happiness of other residential aspects

	(1)	(2)	(3)	(4)
	The whole sample		Non-market housing sample	
A. Happiness about living convenience				
Rail access				
station distance <2km	-0.037**	-0.033*	-0.045*	-0.036**
	(0.016)	(0.018)	(0.023)	(0.015)
station distance >2km	-0.022	-0.019	-0.015	-0.011
	(0.026)	(0.030)	(0.023)	(0.023)
Household income	Yes	Yes	Yes	Yes
Other household characteristics	Yes	Yes	Yes	Yes
Time effect	Yes	Yes	Yes	Yes
Location characteristics	No	Yes	No	Yes
Within R^2	0.349	0.356	0.436	0.448
Sample size	1633	1633	1338	1338
Fixed effects variance share	0.577	0.571	0.669	0.662
B. Happiness about social environment				
Rail access				
station distance <2km	0.048**	0.033**	0.053**	0.045**
	(0.023)	(0.016)	(0.025)	(0.021)
station distance >2km	0.032	0.015	0.024	0.011
	(0.021)	(0.022)	(0.015)	(0.023)
Household income	Yes	Yes	Yes	Yes
Other household characteristics	Yes	Yes	Yes	Yes
Time effect	Yes	Yes	Yes	Yes
Location characteristics	No	Yes	No	Yes
Within R^2	0.326	0.331	0.335	0.356
Sample size	1633	1633	1338	1338
Fixed effects variance share	0.619	0.612	0.653	0.646
C. Happiness about traffic pollution				
Rail access				
station distance <2km	-0.035**	-0.031*	-0.045**	-0.039*
	(0.015)	(0.018)	(0.019)	(0.022)
station distance >2km	0.012	0.008	0.016	0.013
	(0.025)	(0.022)	(0.027)	(0.018)
Household income	Yes	Yes	Yes	Yes
Other household characteristics	Yes	Yes	Yes	Yes
Time effect	Yes	Yes	Yes	Yes
Location characteristics	No	Yes	No	Yes
Within R^2	0.332	0.351	0.396	0.382
Sample size	1633	1633	1338	1338
Fixed effects variance share	0.611	0.602	0.636	0.631

Notes.---The dependant variable in the specifications A-C is the log of happiness of living convenience, social environment, and traffic pollution, respectively. Each specification is a separate set of regressions. Columns (1)-(2) is estimated using the whole sampled residents. Columns (3)-(4) is estimated based on the non-market housing sample.

Table 6 Rail access and homeowners' happiness disaggregated by income and age

	Commuting (1)	Safety (2)	Social (3)	Living (4)	Pollution (5)	Commuting (6)	Safety (7)	Social (8)	Living (9)	Pollution (10)
	The whole sample					Non-market housing sample				
Group 1 (low age*low income)										
station distance <2km	-0.016*	0.013	0.016	-0.029	-0.033*	-0.023*	0.027	0.021	-0.042	-0.031*
	(0.009)	(0.018)	(0.011)	(0.018)	(0.019)	(0.012)	(0.034)	(0.015)	(0.038)	(0.018)
station distance >2km	-0.011	0.010	0.006	-0.007	0.011	-0.006	0.025	0.006	-0.014	0.009
	(0.008)	(0.009)	(0.010)	(0.005)	(0.008)	(0.010)	(0.018)	(0.014)	(0.018)	(0.016)
Within R^2	0.411	0.427	0.302	0.352	0.380	0.461	0.409	0.332	0.355	0.353
Sample size	496	496	496	496	496	380	380	380	380	380
Fixed effects variance share	0.906	0.795	0.758	0.594	0.640	0.884	0.983	0.932	0.516	0.614
Group 2 (low age*high income)										
station distance <2km	-0.109**	0.048*	0.039**	-0.031**	-0.056*	-0.149**	0.052**	0.042*	-0.056**	-0.055**
	(0.045)	(0.027)	(0.018)	(0.014)	(0.032)	(0.58)	(0.021)	(0.019)	(0.025)	(0.028)
station distance >2km	-0.062	0.023	0.010	-0.013	0.029	-0.061	0.021	0.025	-0.019	0.017
	(0.058)	(0.022)	(0.012)	(0.035)	(0.018)	(0.083)	(0.013)	(0.018)	(0.025)	(0.015)
Within R^2	0.432	0.312	0.326	0.311	0.302	0.503	0.486	0.403	0.345	0.305
Sample size	425	425	425	425	425	335	335	335	335	335
Fixed effects variance share	0.954	0.930	0.798	0.687	0.885	0.896	0.697	0.616	0.790	0.776
Group 3 (high age*low income)										
station distance <2km	-0.039**	0.033*	0.021*	-0.026	-0.012	-0.033*	0.026*	0.026*	-0.016	-0.027
	(0.023)	(0.019)	(0.011)	(0.023)	(0.009)	(0.018)	(0.014)	(0.014)	(0.028)	(0.019)
station distance >2km	-0.022	0.008	0.003	-0.055	0.008	-0.015	0.010	0.007	-0.006	0.020
	(0.043)	(0.035)	(0.005)	(0.057)	(0.013)	(0.036)	(0.029)	(0.033)	(0.010)	(0.046)
Within R^2	0.439	0.304	0.316	0.234	0.309	0.428	0.410	0.306	0.383	0.334
Sample size	411	411	411	411	411	360	360	360	360	360
Fixed effects variance share	0.515	0.690	0.570	0.625	0.936	0.768	0.823	0.712	0.829	0.559
Group 4 (high age*high income)										
station distance <2km	-0.132**	0.067*	0.038**	-0.048**	-0.040***	-0.151**	0.072**	0.056**	-0.069**	-0.065**
	(0.061)	(0.035)	(0.017)	(0.023)	(0.015)	(0.066)	(0.035)	(0.024)	(0.035)	(0.030)
station distance >2km	-0.078	0.015	0.012	-0.013	0.021	-0.023	0.009	0.025	-0.015	0.025
	(0.083)	(0.010)	(0.071)	(0.009)	(0.022)	(0.093)	(0.013)	(0.072)	(0.028)	(0.021)
Within R^2	0.413	0.321	0.218	0.382	0.411	0.530	0.513	0.401	0.412	0.387
Sample size	301	301	301	301	301	263	263	263	263	263
Fixed effects variance share	0.779	0.603	0.882	0.750	0.901	0.931	0.756	0.870	0.679	0.688

Notes.--- Each column and group is a separate regression with full set of controls. Dependent variable in columns (1)–(5) and (6)-(10) is the log happiness of commuting convenience, traffic safety, social environment, living convenience and traffic pollution, respectively. Groups 1-4 are classified by using sample median income and age level. Standard errors corrected for clustering at the cell unit level are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 7 Regression estimates of rail access effects, sensitivity analyses

	Commuting (1)	Safety (2)	Social (3)	Living (4)	Pollution (5)	Commuting (6)	Safety (7)	Social (8)	Living (9)	Pollution (10)
	The whole sample					Non-market housing sample				
A. Baseline estimates (N=1633)										
station distance <2km	-0.051**	0.046**	0.033**	-0.033*	-0.031*	-0.088**	0.038**	0.045**	-0.036**	-0.039*
	(0.026)	(0.023)	(0.016)	(0.018)	(0.018)	(0.040)	(0.018)	(0.021)	(0.015)	(0.022)
station distance >2km	-0.028	0.025	0.015	-0.019	-0.008	-0.039	0.019**	0.011	-0.011	-0.013
	(0.046)	(0.018)	(0.022)	(0.030)	(0.022)	(0.032)	(0.011)	(0.023)	(0.023)	(0.018)
B. 1km distance band (N=1610)										
station distance <1km	-0.058***	0.056*	0.030*	-0.035*	-0.025*	-0.093**	0.048**	0.041**	-0.030**	-0.043**
	(0.022)	(0.030)	(0.018)	(0.019)	(0.015)	(0.041)	(0.021)	(0.016)	(0.014)	(0.021)
station distance >1km	-0.026	0.012	0.003	-0.024	-0.005	0.052	0.014*	0.006	-0.012	-0.005
	(0.027)	(0.008)	(0.037)	(0.035)	(0.023)	(0.038)	(0.008)	(0.022)	(0.016)	(0.011)
C. 4km distance band (N=1676)										
station distance <4km	-0.049*	0.051	0.016	-0.055*	-0.023	-0.078*	0.039	0.032	-0.045**	-0.036
	(0.028)	(0.044)	(0.011)	(0.032)	(0.019)	(0.045)	(0.032)	(0.029)	(0.024)	(0.028)
station distance >4km	-0.035	0.023	0.009	-0.031	-0.012	-0.069	0.018*	0.016	-0.022	-0.007
	(0.081)	(0.018)	(0.043)	(0.035)	(0.034)	(0.052)	(0.010)	(0.018)	(0.031)	(0.023)
D. Dropping central city sample (N=1235)										
station distance <2km	-0.193***	0.056**	0.031**	-0.036*	-0.026**	-0.231***	0.046**	0.038*	-0.032**	-0.032**
	(0.031)	(0.023)	(0.015)	(0.020)	(0.013)	(0.027)	(0.023)	(0.022)	(0.014)	(0.016)
station distance >2km	-0.048	0.019	0.008	-0.021	-0.008	-0.052*	0.013**	0.041	-0.011	-0.006
	(0.055)	(0.012)	(0.026)	(0.038)	(0.021)	(0.031)	(0.006)	(0.065)	(0.020)	(0.008)
E. Using public commuter sample (N=1338)										
station distance <2km	-0.056**	0.043*	0.013	-0.039**	-0.028*	-0.097**	0.036**	0.026*	-0.043**	-0.048*
	(0.023)	(0.024)	(0.012)	(0.016)	(0.016)	(0.058)	(0.017)	(0.014)	(0.018)	(0.025)
station distance >2km	-0.022	0.017	0.005	-0.025	-0.007	-0.042	0.015**	0.008	-0.010	-0.006
	(0.050)	(0.012)	(0.028)	(0.021)	(0.022)	(0.035)	(0.007)	(0.029)	(0.029)	(0.015)

Notes. --- Dependent variable in columns (1)–(5) and (6)-(10) is the log happiness of commuting convenience, traffic safety, social environment, living convenience, and traffic pollution, respectively. Specification A shows the baseline estimates reported in Tables 3-5. Specifications B-C use different distance bands to select the treatment group, as described in the text. Specification D is similar to specification A except for dropping the central city sample. The sample used in specification E only includes homeowners who use public transport to work and hold the tenure before the transport was improved. Each column and specification is a separate regression. All regressions shown in the table include the full set of controls. Standard errors corrected for clustering at the cell unit level are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 8 Benefits of the transport improvements in the Beijing urbanized area (CNY/month)

			Welfare measures for improved rail access														
			Commuting convenience			Traffic safety			Social environment			Living convenience			Traffic pollution		
	Average monthly household income (CNY)	Distance reduction (km)	Mean	P20th income	P80th income	Mean	P20th income	P80th income	Mean	P20th income	P80th income	Mean	P20th income	P80th income	Mean	P20th income	P80th income
Entire urbanized area																	
Whole sample	6533	1.15	1136	716	1828	-489	-184	-675	-378	-256	-711	622	356	1261	433	387	866
non-market housing sample	5946	1.03	1095	464	1579	-595	-395	-906	-489	-380	-816	737	251	1325	558	368	963
Central city only																	
Whole sample	6601	0.78	881	653	1287	-521	-234	-772	-590	-325	-912	516	327	1021	568	465	920
non-market housing sample	6180	0.72	796	498	1016	-615	-458	-1134	-677	-469	-1126	575	212	1138	685	483	1040
Suburb only																	
Whole sample	6494	1.20	1368	845	2196	-418	-131	-556	-228	-169	-542	654	381	1293	391	106	726
non-market housing sample	5911	1.13	1165	778	1831	-557	-368	-834	-316	-230	-608	808	288	1396	445	211	752

Note.--- Welfare estimates are calculated by using the equation (4) and (5), as described in the text. The whole sample represents the sampled homeowners who work and hold the tenure before the transport improvement happened. The non-market housing sample means the long-term tenure homeowners who work and lived in non-market (*fang gai*) housings with pre-determined locations. "P20th income" and "P80th income" represent the 20th and 80th income percentile, respectively. 1GBP= around 10 CNY.

Figure list

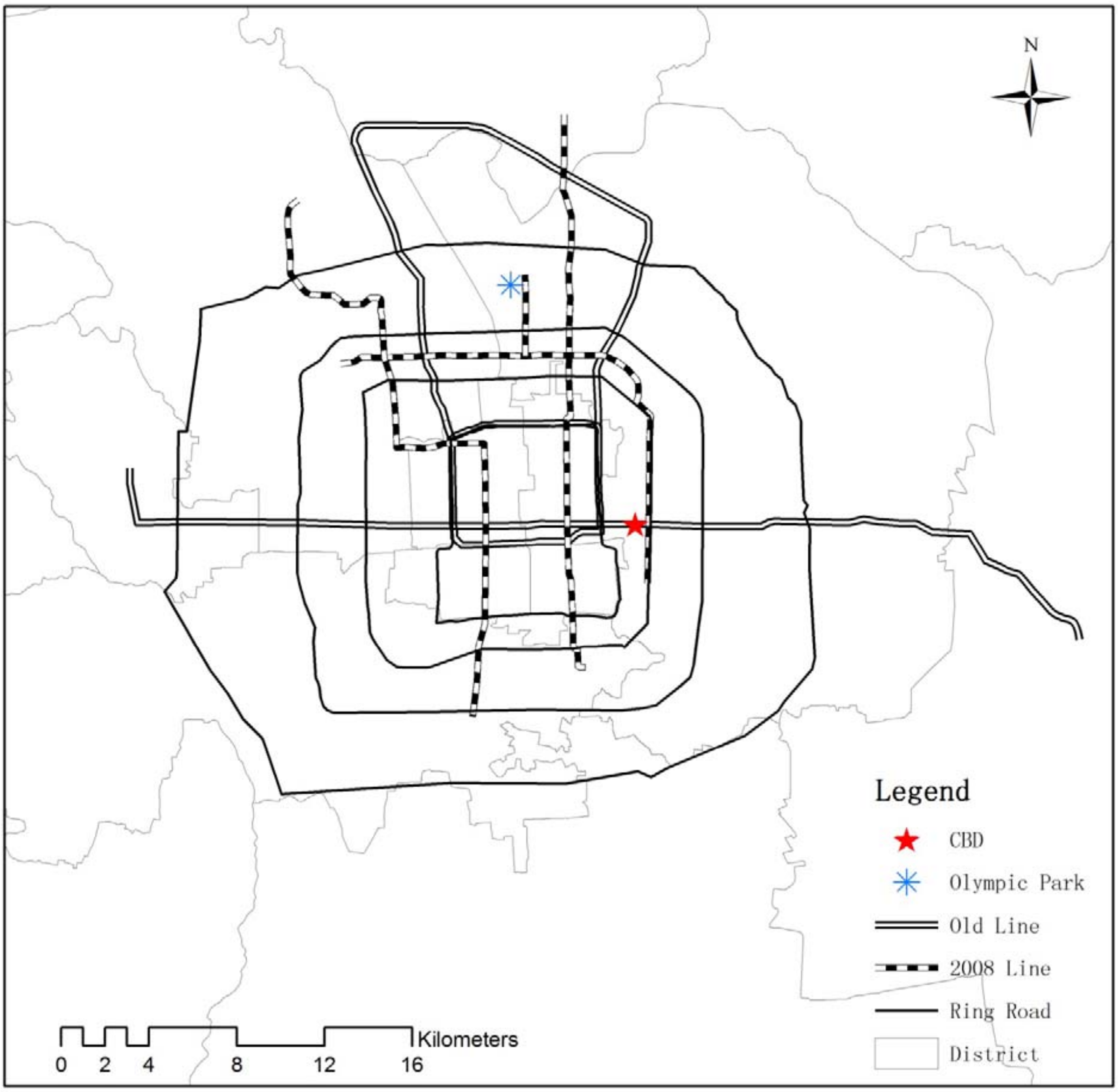


Figure 1 New rail transit constructions in 2008 Beijing

Notes.---Old Line means the subway lines built before 2008; 2008 Line means the newly-opened subway lines around 2008.

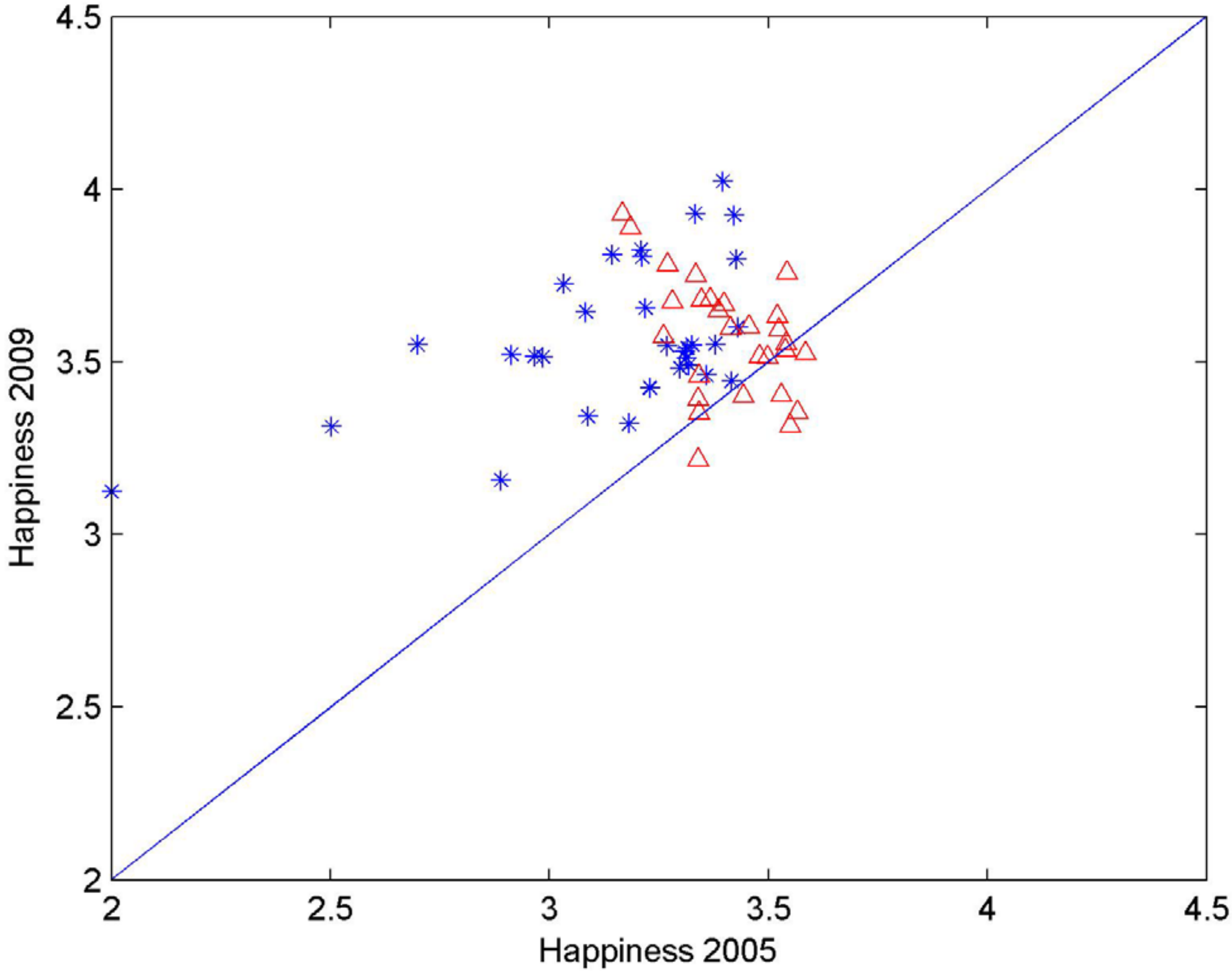


Figure 2 Happiness changes in commuting convenience within 2km new station area: the whole sample

Notes.---Each triangle-dot represents the median happiness value within 2km of a new station located at the central city. Each star-dot represents the median happiness value within 2km of a new station located at the suburbs. The solid line is the 45 degree line. Happiness value is measured on a scale from "1 being very unhappy" to "5 being very happy". The horizontal axis is the median 2005 happiness value of commuting convenience. The vertical axis is the median 2009 happiness value of commuting convenience.

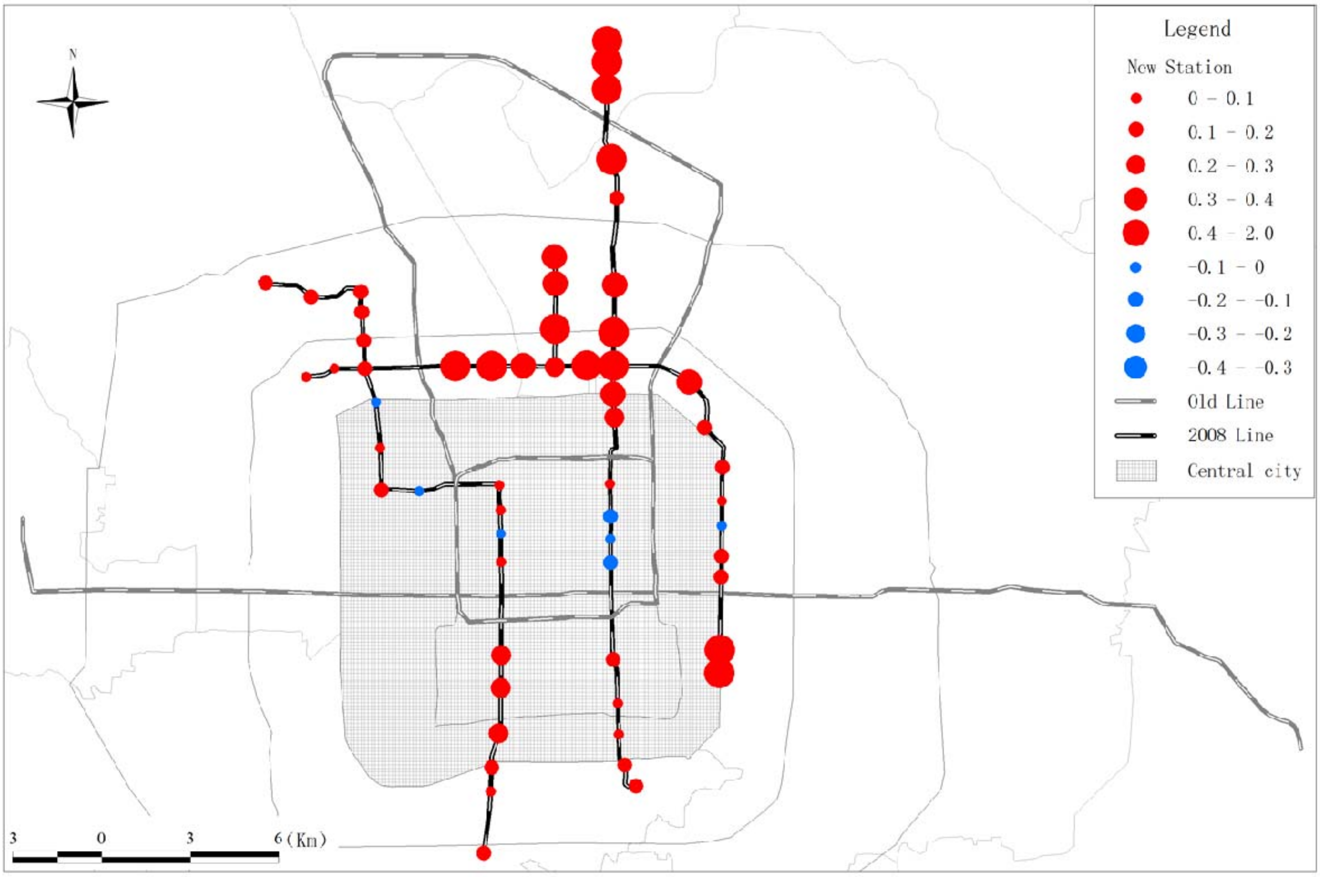


Figure 3 Spatial distributions of happiness changes within 2km new station area: the whole sample

Notes.---Each circle label represents the vertical deviation of each dot in Figure 2 from the 45 degree line, as described in the text.

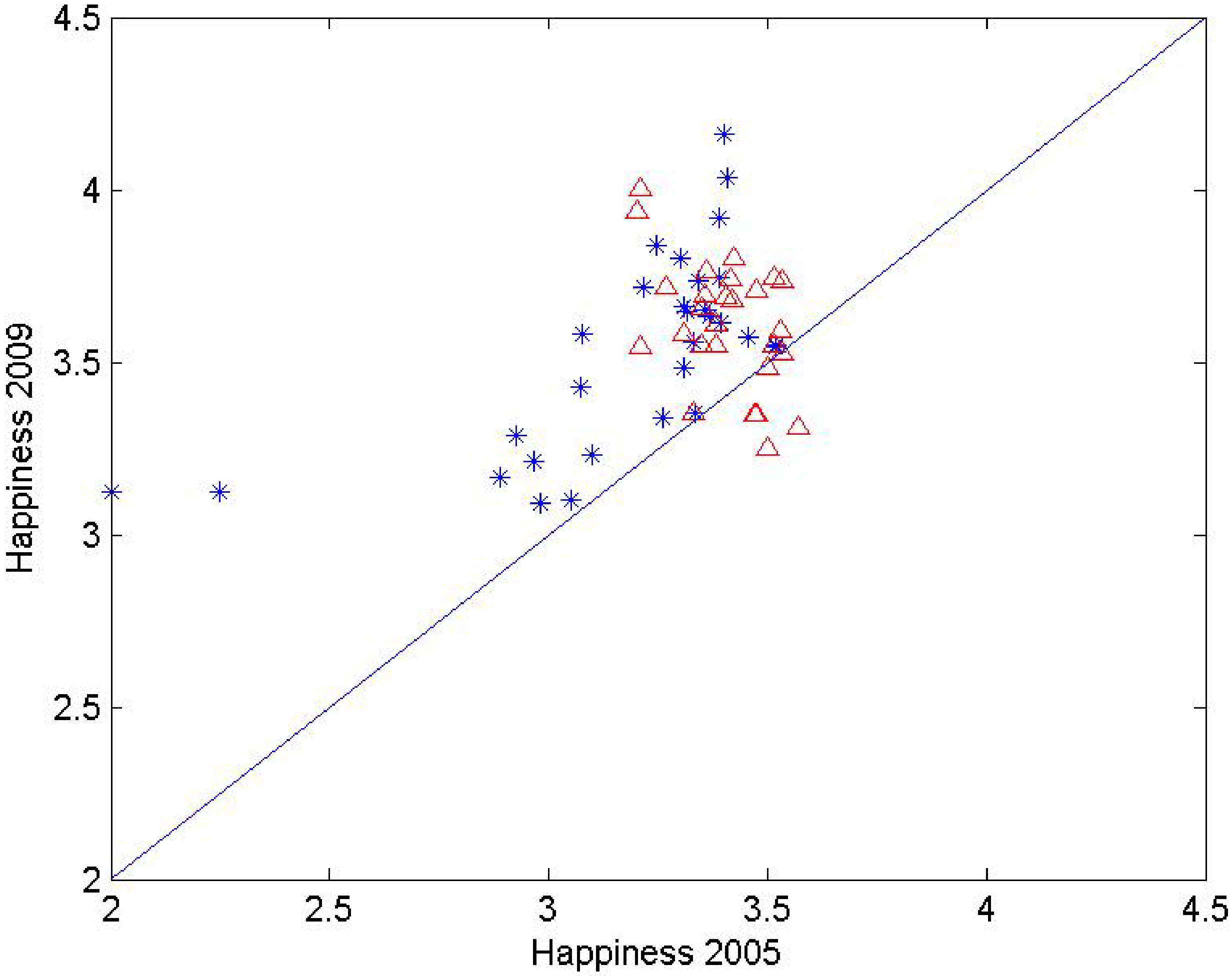


Figure 4 Happiness changes in commuting convenience within 2km new station area: non-market housing sample

Notes.--- Each triangle-dot represents the median happiness value within 2km of a new station located at the central city. Each star-dot represents the median happiness value within 2km of a new station located at the suburbs. See other notes in Figure 2.

Figure 5 Spatial distributions of happiness changes within 2km new station area: non-market housing sample

Notes.---Each circle label represents the vertical deviation of each dot in Figure 4 from the 45 degree line, as described in the text.

Appendix A.

Appendix Table 1 Happiness survey questions

Happiness indicator	Original survey question	Measurement	Expected signs after transport improved	Possible reasons
Commuting convenience	How well do you satisfy your residential location about its local (neighbourhood) area's convenience to use rail transit to do work-related activities?	0= not familiar ; 1 = very unhappy; 2 = unhappy; 3=normal; 4 = happy; 5 = very happy	Happiness rise	Commuting time-savings by living closer to stations
Living convenience	How well do you satisfy your residential location about its local (neighbourhood) area's convenience to use rail transit to do non-working related activities?	0= not familiar ; 1 = very unhappy; 2 = unhappy; 3=normal; 4 = happy; 5 = very happy	Happiness rise	Time-savings for doing life activities by living closer to stations
Traffic pollution	How well do you satisfy your residential location about its local (neighbourhood) area's traffic pollution conditions (including automobile gas emission and other concerns about the pollution induced by traffic facilities)?	0= not familiar ; 1 = very unhappy; 2 = unhappy; 3=normal; 4 = happy; 5 = very happy	Unclear	A positive impact could be due to the reduced local road traffic and cleaning station conditions compared with before; A negative impact could be caused by crowded traffic and dirty parking spaces at station areas
Traffic safety	How well do you satisfy your residential location about its local (neighbourhood) area's traffic accidents and station areas' safety conditions?	0= not familiar ; 1 = very unhappy; 2 = unhappy; 3=normal; 4 = happy; 5 = very happy	Happiness fall	Safety concerns caused by growing population flows at station areas
Social environment	How well do you satisfy your residential location about its local (neighbourhood) area's social environment (including social culture, social capital, common-sense of worth and other related concerns about social environment)?	0= not familiar ; 1 = very unhappy; 2 = unhappy; 3=normal; 4 = happy; 5 = very happy	Happiness fall	Noise and congestion effects caused by growing population flows at station areas

Appendix B.

Appendix Table 2 Vertical deviation of happiness changes within 2km new station area

Station Name	Vertical deviation (1)	(2)	Location (3)	Station Name	Vertical deviation (1)	(2)	Location (3)
tiantongyuanbei	0.80	0.80	1	suzhoujie	0.02	0.16	1
tiantongyuan	0.57	0.80	1	bagou	0.07	0.08	1
tiantongyuannan	0.60	0.62	1	yuanmingyuan	0.16	0.19	1
lishuiqiaonan	0.43	0.20	1	beigongmen	0.12	0.01	1
beiyuanlubei	0.18	0.08	1	xiyuan	0.13	0.12	1
datunludong	0.37	0.04	1	beijingdaxuedongmen	0.20	0.28	1
huixinxijiebeikou	0.49	0.36	1	zhongguancun	0.14	0.23	1
huixinxijienankou	0.47	0.42	1	renmindaxue	-0.09	0.01	0
hepingxiqiao	0.36	0.21	0	weigongcun	0.04	0.19	0
hepinglibeijie	0.29	0.16	0	guojiatushuguan	0.10	0.18	0
anzhenmen	0.44	0.35	1	dongwuyuan	-0.03	0.12	0
mudanyuan	0.44	0.54	1	ciqikou	0.13	0.27	0
jiandemen	0.36	0.37	1	tiantandongmen	0.08	0.23	0
beitucheng	0.26	0.25	1	puhuangyu	0.01	0.14	0
xitucheng	0.42	0.44	1	liujiayao	0.16	0.02	1
aolinpikezhongxin	0.42	0.36	1	songjiazhuang	0.16	0.02	1
aolinpikegongyuan	0.40	0.25	1	caishikou	0.23	0.32	0
senlingongyuannanmen	0.39	0.18	1	taoranting	0.22	0.24	0
beixinqiao	0.03	0.02	0	beijingnanzhan	0.22	0.24	0
dongsi	-0.09	-0.09	0	majiabao	0.14	0.06	1
zhangzizhonglu	-0.15	-0.09	0	jiaomenxi	0.10	0.10	1
dengshikou	-0.17	-0.18	0	gongyixiqiao	0.19	0.26	1
xinjiekou	0.01	-0.18	0	jintaixizhao	0.19	0.14	0
pinganli	0.01	-0.01	0	hujialou	0.19	0.16	0
xisi	-0.04	-0.01	0	tuanjiehu	-0.01	-0.01	0
lingjinghutong	0.05	0.02	0	nongyezhanlanguan	0.08	0.04	0
shuangjing	0.54	0.56	0	liangmaqiao	0.15	0.16	0
jinsong	0.50	0.52	0	sanyuanqiao	0.12	0.21	1
haidianhuangzhuang	0.12	0.25	1	taiyanggong	0.31	0.16	1
				yonganli	0.28	0.28	0

Notes.---Columns (1) and (2) report the vertical deviation of the median happiness of commuting convenience within 2km of each new station area from the 45 degree line shown in the Figures 2 and 4 respectively. Column (3) indicates whether a new station is located in the suburb or not (suburb stations=1, central city stations=0).

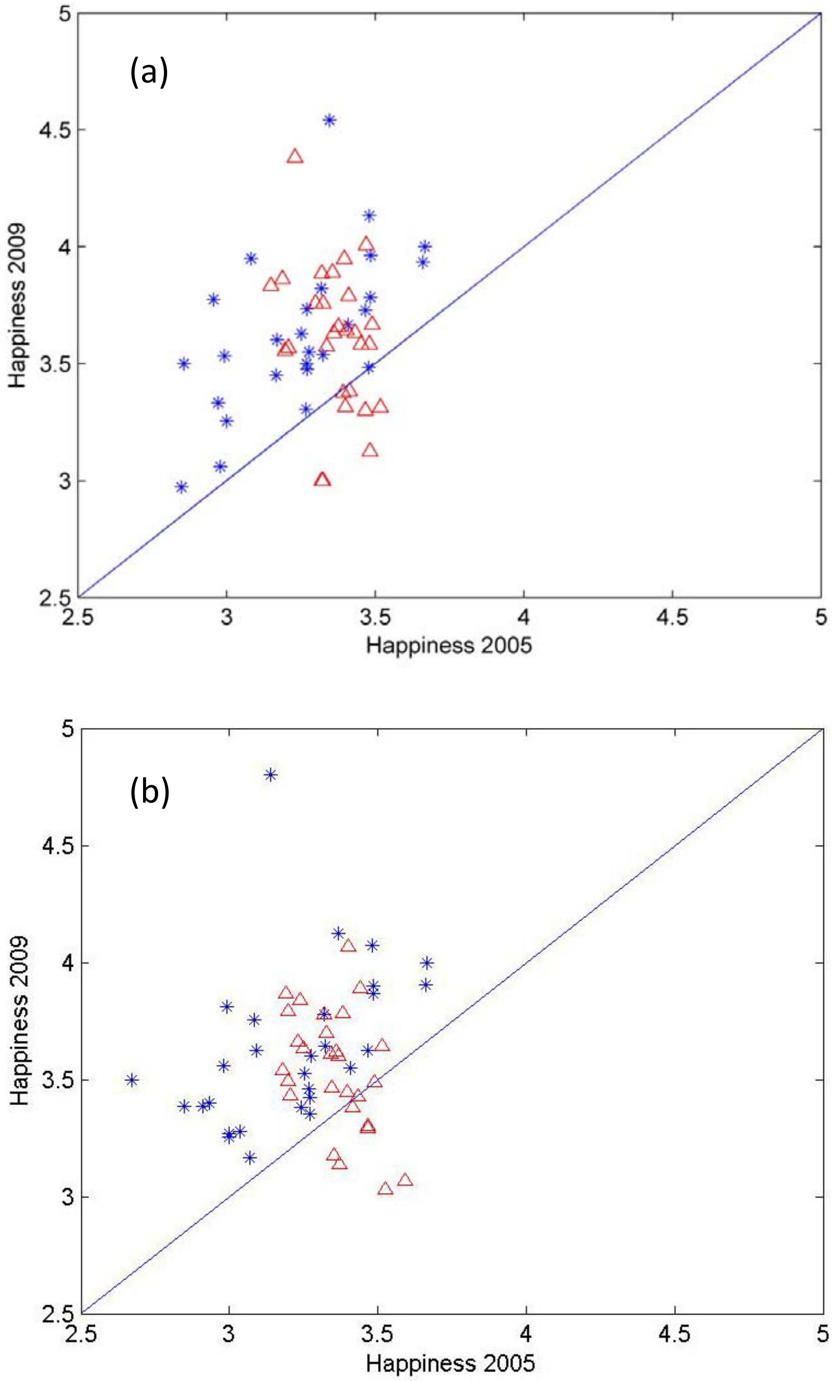
Appendix C.

Appendix Table 3 Variable name and definitions

Variable name	Definition
Household characteristics	
Income	Monthly household wages (in CNY 1000): 1 = 30 and less; 2 = 31–50; 3=51–100; 4 = 101–150; 5 = 151–200; 6 = 200 and above
Age	Age of the respondent (years). 1=young age:18-39; 0=others
Family size	Number of the family members in each household
Housing size	in m^2
Job rank	The job rank status: 1=entry-level job rank and below; 2=middle-level job rank; 3=high-level job rank and above
Education attainment	Highest education level:1 = primary school and lower; 2 = high school; 3 = undergraduate; 4 = postgraduate and above
Commuting time	one-way commuting time to work in minutes
Location characteristics	
CBD distance	Distance to the Beijing's central business district (CBD) in kilometres
School distance	Distance to the nearest middle school*school rank in kilometres
Park distance	Distance to the nearest park in kilometres
Bus stop distance	Distance to the nearest bus stop in kilometres
River	Indicator of proximity of cell unit to rivers (<500 meters)
Expressway	Indicator of proximity of cell unit to the expressway, ring road and primary road (<500 meters)
Airport	Indicator of proximity of cell unit to airport (<5 kilometre)
Olympic	Indicator of proximity of cell unit to the Olympic park (<2 kilometre)
Bedroom $Area_i$	Indicator of proximity of cell unit to the bedroom communities of *Yizhuang, Tiantongyuan, Tongzhou, Daxing* respectively (<2 kilometre)
Commuting mode	Proportion of public transport users in cell unit (%)
Employment Density	Total employment density in each zone (employees per km^2)
Population Density	Total population density in each zone (persons per km^2)
Old Building	Ratio of buildings built before 1949 in each zone (%)
Education Attainment	Median educational attainment in each zone:1=middle school or lower;2=high school;3=university;4=post graduate
Crime	Number of crimes per 1000 person in each zone
Public Housing	Percentage of people renting public housing in each zone

Notes.---All variables are aggregated to cell-unit, pre-post of the transport improvement, and used in regressions as controls.

Appendix D.

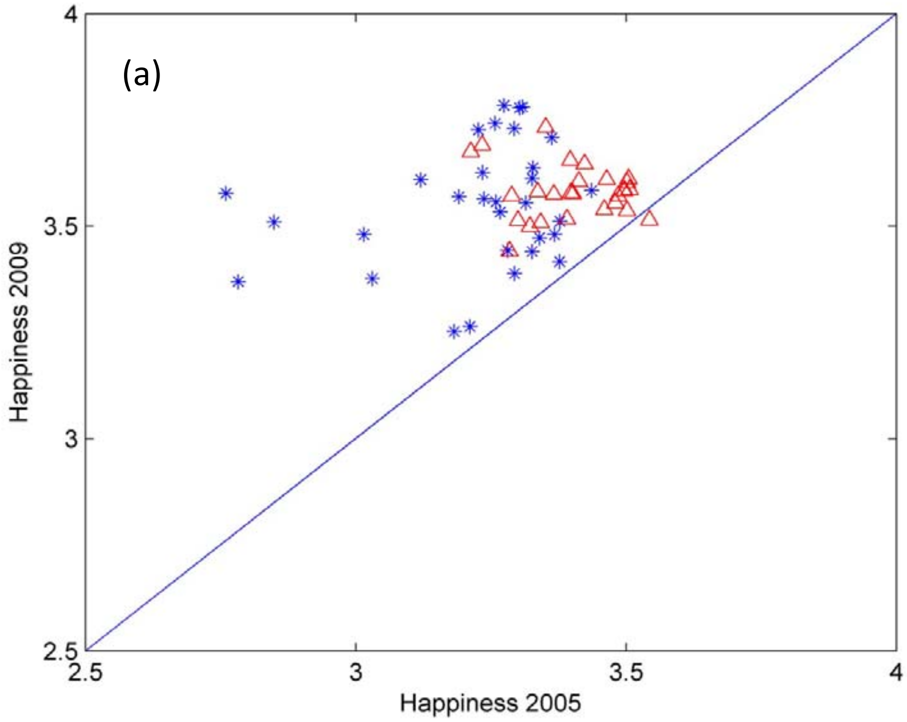


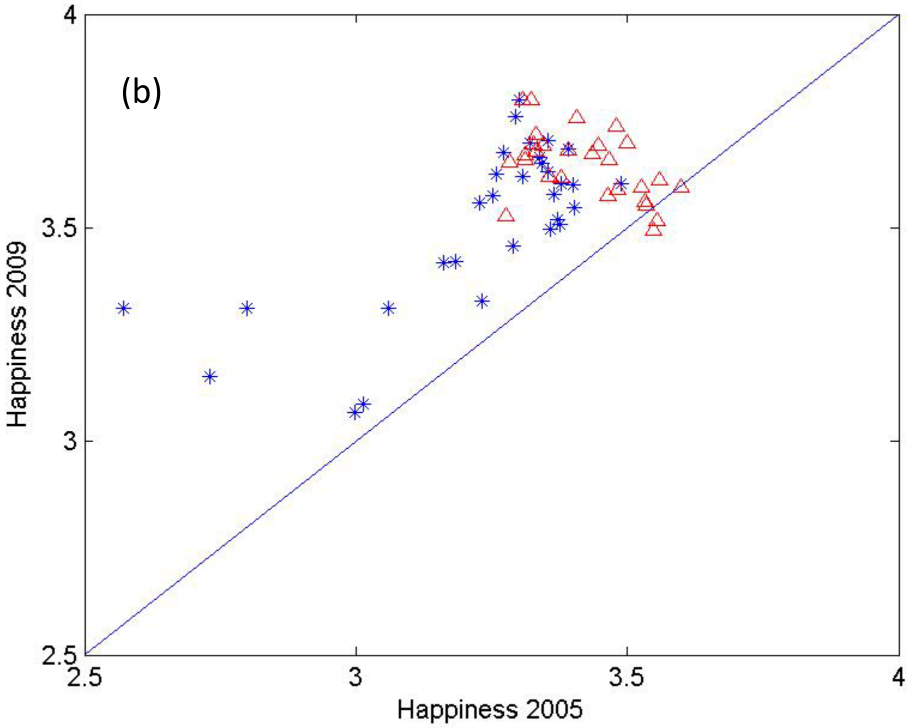
Appendix Figure 2 Happiness changes within 1km new station area

Notes.---Figure (a) shows the pattern of the whole sampled homeowners' median happiness value of commuting convenience within 1km of a new station. Figure (b) shows the pattern of non-market housing homeowners' median happiness value of commuting convenience within 1km of a new station.

Appendix Figure 3 Spatial distributions of happiness changes within 1km new station area

Notes.--- Figures (a) and (b) show the spatial distributions of changes in median value of happiness towards commuting convenience by using the whole sample and the non-market housing sample, respectively. Each circle label represents the vertical deviation of each dot in Appendix Figure 2 (a-b) from the 45 degree line accordingly.





Appendix Figure 4 Happiness changes within 4km new station area

Notes.---Figure (a) shows the pattern of the whole sampled homeowners' median happiness value of commuting convenience within 4km of a new station. Figure (b) shows the pattern of non-market housing homeowners' median happiness value of commuting convenience within 4km of a new station.

Appendix Figure 5 Spatial distributions of happiness changes within 4km new station area

Notes.--- Figures (a) and (b) show the spatial distributions of changes in median value of happiness towards commuting convenience by using the whole sample and the non-market housing sample, respectively. Each circle label represents the vertical deviation of each dot in Appendix Figure 4 (a-b) from the 45 degree line accordingly.

BIS Department for Business Innovation & Skills

E·S·R·C ECONOMIC & SOCIAL RESEARCH COUNCIL

Llywodraeth Cynulliad Cymru
Welsh Assembly Government

Spatial Economics Research Centre (SERC)
London School of Economics
Houghton Street
London WC2A 2AE

Tel: 020 7852 3565
Fax: 020 7955 6848
Web: www.spatialeconomics.ac.uk

SERC is an independent research centre funded by the Economic and Social Research Council (ESRC), Department for Business Innovation and Skills (BIS) and the Welsh Assembly Government.