Residential Satisfaction, Crowding and Density: Evidence over Different Geographic Scales in Auckland☆

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Abstract

Concentrating on objective measures of an individual household's situation may be insufficient when dealing with the determinants of the satisfaction with residential environment. There is a long history of relative measurement in the economics literature, especially in welfare studies, in which 'keeping up with the Joneses' may play an important role in people's evaluations of their different life circumstances. Conceptually, the reference group for the relative measurement refers to people who affect the individual the most. Neighbours, as a group who live shoulder-to-shoulder with the person, may be the relevant reference group for some situations. In this study, we analyse the role of relative residential positions, in relation to neighbours, in addition to the household's absolute residential position in determining the satisfaction of residents. Reference groups are considered as neighbours living over different geographic scales, neighbours who are the symbols of success over different geographic scales, and neighbours who may be visited in a 5-minute walk. Results indicate that while absolute crowding and absolute density affect residential satisfaction negatively, none of the relative crowding measures affect residential satisfaction significantly. Further investigations would be needed to find an optimal reference group and an optimal set of subjective measures for social comparisons.

Keywords: Neighbourhood satisfaction; housing satisfaction; crowding; population density; perceived density; relative crowding; social comparison.

JEL codes: C21; I31; R23.

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1 Introduction

While one of the major goals of the urban development schemes is to increase residential satisfaction, there is, as yet, little evidence as to the effectiveness of such schemes delivering increased satisfaction. Residential satisfaction consists of a range of objective, as well as subjective, factors. People usually compare themselves to a reference group. In addition to any objective surrounding environmental characteristics, people's subjective evaluations often depend on their relative position within a reference group.

As concluded by Torshizian and Grimes (2014), amongst three measures of crowding including Perceived density (PD), Canadian National Occupation Standard (CNOS) and Room Density (RD), the one comprising individuals' perception (PD) is the best predictor for their residential satisfaction. This bears in mind the importance of subjective evaluations, which depends on the relative position of an individual.

Despite of the long history of relative measurement in the economics literature, the reference group is often not specified in the studies. The word 'reference group' can be understood as those who affect an individual the most. Neighbours, as a group who live shoulder-to-shoulder with the person, may comprise the relevant reference group for some issues (see for example Clark, Westergård‐Nielsen, & Kristensen, 2009). Thus, in this study, we are interested in the impact of relative measures, which measure the relative position of an individual, as well as the impact of the absolute measures, on residential satisfaction. We base our relative indicators on objective measures of the neighbourhood by comparing the individual's crowding and population (area) density with the average crowding and the average area density of his/her neighbourhood.

Easterlin (1978) in his seminal study on the economics of happiness, emphasises the role of people's relative positions as a factor that negatively affects their happiness. He suggests that when people subjectively evaluate the position of another and proceed to judge themselves according that subjective evaluation, they feel less satisfied than they would have done were they in a position to make an objective assessment. Easterlin introduces the following statement from Karl Marx as a motivation for his study:

> "A house may be large or small; as long as the surrounding houses are equally small it satisfies all social demands for a dwelling. But if a palace rises beside the little house, the little house shrinks into a hut" (as quoted in Lipset, 1960, p. 63).

Following Easterlin's study, the recent wave of well-being studies emphasises the role of relative positions. Relative income is often considered as the variable of interest. The idea is that people feel satisfied/dissatisfied as a result of comparing their income with the income of others, who are known as the reference group. A large body of the literature confirms the existence of a negative correlation between satisfaction and the relative income level. Therefore, in a neighbourhood, a person's utility falls once her neighbour's income increases[1].

To extend these studies, we need a better understanding of their two main components, namely the reference group and the variable of interest. As Clark (2012) mentions, people may compare themselves with others including their household members, people with similar characteristics (peer group), neighbours, colleagues or with themselves in the past. Comparisons with others are known as social comparison and comparisons with oneself in the past are known as adaptation. In a study by Knight and Gunatilaka (2010), a change in the reference group is introduced as the main reason for the lower levels of well-being amongst Chinese rural-urban migrants.

[1] Then she probably compensates for this feeling of deprivation by increasing her work efforts.

In a Chinese survey used by Kingdon and Knight (2007), respondents were asked about their reference group. The majority of them (68%) stated that they compare themselves with other individuals in their own village, which is a sign of the importance of geographic proximities. Thus, in this study, the validity of the neighbours' reference group at different geographic scales should be checked on, which widely depends on people's understanding of the boundaries of their surrounding neighbourhood. A comparison group may consist of people living 'over the road' or people living within the boundaries of an individual's bespoken neighbourhood. The other potential reference group consists of people who are perceived as being more successful.

The second component of well-being studies to be considered is the variable of interest, which is often constructed based on a nominal variable, such as income. For instance, by taking a ranking approach, Clark, Westergård-Nielsen and Kristensen (2009), argue for the effect of relative income in small neighbourhoods on economic satisfaction. They introduce neighbours as the 'right' reference group and discuss the impact of comparisons amongst neighbours. Furthermore, they emphasise the importance of the availability of data at local level[2]. Consequently, the richness of data plays a prominent role in this study. Since in the current study, the output variable, residential satisfaction, depends mostly on the physical aspects, we use real variables in the construction of our relative measures.

As discussed by Torshizian and Grimes (2014), amongst predictors of residential satisfaction, perceived density has the highest marginal effect, which confirms the importance of the crowding factor in people's evaluations of the condition of their residential environment. The marginal effect of raw crowding measures, however, are much less than the subjective one's. This difference may derive from the relative positions of individuals, which are not captured by a raw crowding measure. Therefore, a relative crowding measure constructed based on room density, which is a pure objective measure of crowding, may account for comparisons amongst people. Room density (RD) is measured as follows:

$$RD = \frac{Number\ of\ people\ in\ the\ dwelling}{Number\ of\ bedrooms} \quad (1)$$

The chance of accessing green spaces are not equal amongst different neighbourhoods. This is often the case that people located in business centres benefit less from public green spaces. In a study by Barbosa et al. (2007), the distance of different social sectors, including symbols of success, happy families and blue collars, from public green spaces is reported. They have concluded that elderlies and most deprived social groups enjoy the highest access to public green spaces. Therefore, even though people may not live in a crowded dwelling, they may think of a greener neighbourhood in their evaluations of the condition of their living environment.

The paper is organised as follows. Section 2 reviews the literature. This includes an introduction to residential satisfaction; the definitions and differences of crowding measures; the neighbourhood effects and the definitions of neighbourhood boundaries; and an explanation of the average approach taken in this study. Section 3 describes the data sets.

Section 4 presents the constructions of relative measures. In this section, a ratio and a variation approach are taken. As presented in this section, relative measures are calculated based on a comparison with neighbours at different geographic boundaries, a comparison with successful people at different geographic boundaries and a comparison with people who may be visited in a 5-minute walk around the living area. The following section presents descriptive statistics. The last section has our concluding remarks, considering the 4 best-fit models, and suggestions for the future research.

[2] They have used the ECHP survey data, which is a Danish sample of European Community Household Panel with eight waves over 1994 – 2001.

2 Literature review

In this section, the definition of residential satisfaction and the plausible measurement errors in identifying the factors of residential satisfaction are presented. Then the differences between crowding and density are clarified. In the next subsection, the importance of a clear definition of neighbourhood boundaries in identifying the effects of neighbourhoods on the residents is discussed. This is a lead-in to the next discussion on the average approach, which will be taken in the construction of relative measures. In the last part, a review of the studies on the impact of individual and household socio-demographic characteristics on residential satisfaction is presented.

2.1 Residential satisfaction measurement

Some previous studies have studied dwelling satisfaction and neighbourhood satisfaction separately despite the fact that these two have a high correlation (Amérigo & Aragonés, 1997; Lu, 1999; Rodgers, 1982). In this study, we consider residential satisfaction as a variable, which contains both housing and neighbourhood aspects. This variable is estimated differently amongst different studies. Some measure it by asking respondents about their agreement or disagreement with certain statements on Likert scale base, for example, 1-strongly disagree… 5-strongly agree. In this study, respondents answer the residential satisfaction question of 'How do you feel about where you are currently living' by '1- very dissatisfied… 5- very satisfied', which is an ordered categorical base.

Stemming from cultural backgrounds, respondents may have answered the subjective questions with different degrees of optimism. For example, they might say "as long as I am healthy I am the happiest person". This may lead to the exaggeration of the influence of subjective variables, such as satisfaction with residential environment, which is called over-optimism bias (Larwood & Whittaker, 1977). If someone has a more positive attitude, s/he is more likely to have this attitude towards a number of aspects of life, i.e. a person who states a higher residential satisfaction as a result of his/her extreme positive attitude towards life, might state equally a more optimistic state of health. Consequently, Helliwell (2003) addresses the high association issue by serving the 'perception of an individual about his/her health state' as a control variable (Halpern, 2005). In this study the same variable has been served to control for individual's predisposition to being satisfied or not.

Taking into account the subjective evaluations both with crowding and with other environmental issues may arise some concerns about the accuracy of qualitative data. This issue is addressed in a study by Fabling, Grimes, and Stevens (2012) on the use of qualitative firm data to estimate the firms' relative economic output. They consider a wide range of qualitative data biases, including the cognitive perception problem and the over-optimism problem. In conclusion, the qualitative data with a 'don't know' response choice seems to obtain accurate results. The inclusion of the 'don't know' category, as it is done in the current study, reduces the errors associated with the guess or confusion of respondents and, thus, decreases the inaccuracy in responses. In this study, in addition to this five-level Likert item, respondents have a 'don't know' and 'refused' choice, which leads to a more accurate qualitative measurement.

The misunderstanding of interviewees could cause one potential source of measurement error in residential satisfaction, especially if respondents are not able to distinguish between residential satisfaction and the other aspects of satisfaction. However, this is mitigated, as in the interview respondents were asked about satisfaction with different aspects of life, such as life as a whole, job, leisure, housing. Hence the interviewee should be able to distinguish different aspects of satisfaction from one another.

In New Zealand, the impact of cities on Subjective Well-Being (SWB), happiness and quality of life (three dependent variables) is considered by Morrison (2011). He argues that the differences in outcomes amongst regions derive from differences in the evaluations of people, who are influenced by their living environments. For example, people in denser cities may have a different definition of household crowding. In the study three independent step modeling are served to distinguish the changes in the impact of cities on the three dependent variables. In his study, a number of objective as well as subjective explanatory variables are taken into account. However, in order to study the impact of density differences amongst cities, density and crowding are not presented in the models. In each of the models individual attributes, social capital and accessibility are controlled for. Results indicate that, city effects are more significant for more material based well-being outcomes, such as quality of life, the reason for which may be the higher chance of employment for the residents of denser cities.

2.2 Density and crowding measures

As Churchman (1999) mentions, density may affect people's life from different perspectives. For example, sustainable development, urban form, preferred building design, social issues and values, stress, cognitive and perceptual processes are a number of aspects that can be affected by density. The density measures defined for studying different aspects can be introduced by using three main measures, namely density, perceived density and crowding measures. As it is shown in equation (2), the density measure is defined as the ratio of the number of people living in an area to the unit of area. Thus, density is an objective, quantitative and neutral measure. In some cases, e.g. in psychological studies, it is important to distinguish between an increase in density derived from an increase in the numerator, i.e. an increase in the number of people in an area, or a decrease in the denominator, i.e. a decrease in the area units while the number of people is fixed.

$$Density = \frac{Population\ size}{unit\ of\ area} \qquad (2)$$

Perceived density consists of people's estimate of the number of people living in an area. The perceptions of people are subjective and, hence, widely affected by their socioeconomic status. For example, people with a higher income level may not appreciate living in a less crowded area as much as those with lower income level do. Another subjective density concept is crowding, which is a gauge of individuals' negative evaluation of their density and perceived density. In other words, crowding is a measure of the psychological stress that is associated with the living environment's density. Thus, when the density or perceived density of a given area is considered as high, the area would usually be considered as crowded.

Density can be divided into two aggregates based on its nominator. If the numerator consists of the number of people, as it is in equation (2), it derives population density, also known as area density. If the numerator consists of the number of dwellings, it derives residential density, as it is shown in equation (3). The unit of area differs amongst regions based on the common standard in use, for example it can be km^2, mi^2.

$$Residential\ density = \frac{Number\ of\ dwellings\ in\ an\ area}{unit\ of\ area} \qquad (3)$$

There are two main sources of concern with the definition of density. First, density measures suffer from aggregate measures' pitfalls, i.e. a high population density of a city may be misleading if there would be a huge gap between its neighbourhoods' population density. We can think of such a problem at smaller scales as well, e.g. a high room density in a neighbourhood with a huge gap between households living in the neighbourhood. The other plausible problem with density measures stems from the form of amenities' distribution in areas. For example, given equal density measures of two neighbourhoods, the green spaces may be distributed scattered in one of them whilst concentrated in another, which means their residents do not have an equal chance of benefiting from green spaces. In light of this, the absence of these drawbacks in our subjective measures may lead us to conclude that they are a superior measure to the density measure.

Residential density is considered as a central issue in urban development studies. Transit-oriented development studies are in favour of a mixed use urban development, such that people can walk from their offices to the rail transportation system. In this approach, the dependence on cars should be minimised and open space should be preserved. Compact city development studies also seek a reduction in car usage by designing denser cities with a mixed land use. In the development cost-benefit studies, the wide spread of cities is the main source of concern. While having a higher density is not a necessity in the transit-oriented development, it is necessary in the centralisation approach. Based on energy economics studies, for example, the sprawl development poses a high energy transmission cost on households. Density is also considered in economic, social and ecological sustainability schemes, based on which a sustainable city is not necessarily the dense one.

Depending on the overall understanding of crowding amongst a nation's citizens, measurement of it may vary from a society to another. Thus, a crowding index may be constructed based on specific aspects of the living environment in a region while on another aspects in another regions. The relevance of the people's evaluations and their cultural backgrounds is well-known amongst philosophers as 'Cultural relativism'. For example, sleeping in the living area is prevalent amongst Japanese, though it may not be common amongst other nations. Thus, households with the same characteristics living in similar living environments may be considered to be crowded in one country but not in another. The variation in the definition of indexes may even happen amongst small geographic scale regions, for example amongst municipalities of a region.

Perceived density is derived from objective density and also a range of socioeconomic factors. Previously mentioned measures do not account for the composition of households, while in Australia, Canada, New Zealand and the U.K. the household crowding measure accounts for the composition of households, such as couple status. A popular index that considers the household composition is Canadian National Occupancy Standard (CNOS). Based on this measure, children under 18 years old may share a bedroom if they are of the same sex. In New Zealand, crowding standards are defined based on the Housing Improvement Regulations 1947 (Yoshikawa & Ohtaka, 1989). Based on the HIR, the household is considered to be crowded if it violates some well-defined conditions. In this regulation, children between one and ten years old are counted as half a person and the number of people per bedroom should not exceed two and a half. The children of more than ten years old may share a room only if they are of the same sex. As each person requires a specific amount of floor area, the size of bedrooms is important in this definition of household crowding.

2.3 Neighbourhood effects

Neighbourhood effects have been a controversial issue amongst urban studies during the last two decades. With the introduction of spatial effects in economics, the causality issues were the main source of concern in studies to the extent that some studies challenged the possibility of deriving any reliable result in spatial studies. However, in the presence of appropriate assumptions and by employing appropriate econometric methods we may be able to confirm the reliability of results. In a study on the multiplier effect of the area effects, Galster and Hedman (2013) compare the results derived from multiple methods, including fixed effects panel model, random effects panel model, fixed effects panel model with instrumental variables, fixed effects panel model for a sub-sample and ordinary least squares. They find high sensitivity of results to the statistical approach taken. Regardless of the approach, which will be discussed in section 4, they find significant neighbourhood effects.

Durlauf (2004) introduces two main reasons for the recent interest of economists in studying the effect of neighbourhoods on their residents. One of them is the recent advanced methods in economic theory (for more details see Manski (2000)) and the other is the importance of a comprehensive approach to the persistence of poor conditions amongst poor people over long time periods, or in other words, poverty traps. This happens when the choices of peer groups affect other members of the group. The poverty effects derived from the social interactions amongst peer groups are influenced by three main factors.

The first factor, which most relates to this study, is the psychological factor, whereby people often compare themselves with peer groups. The second and third factors are the dependence of behavioural costs on others' behaviours and the dependence of people's behaviours in the future on the information derived from peers' past behaviours.

To understand the effect of neighbourhoods, first we should have a clear definition of neighbourhood, which has been defined differently amongst studies. Previously it was common to define neighbourhood as a geography that is limited by boundaries defined by administrative units of the government. This definition does not account for individuals' perception about their neighbourhood's boundary, thereby the results of any study at individual levels may be biased. Recently, there are some discussions in favour of bespoke neighbourhood, which is defined based on the mutual characteristics of the residents. The latter definition is based on the assumption that neighbourhoods are homogeneous regions. The correct definition of the neighbourhood seems to depend on the purpose of a study. A study that seeks a more boundaries oriented results, should follow the administrative boundary definitions, while a study on the residents' behaviours may follow the bespoke definition. An appropriate definition of neighbourhood, improves the credibility of results significantly. This will be discussed in section 3.4.

The aggregate and individual effect of neighbourhood is mentioned by Manski (1993) and developed by Durlauf (2004). The neighbourhood effect may be of two types: firstly its impact on individuals and consequently on neighbourhood outcomes, and secondly its impact on neighbourhood membership. To study the influences, they make a distinction between neighbourhood effects derived from individuals' characteristics and from members' mutual behaviour. Then by assuming that a person is more intensely affected by his/her beliefs about others' behaviours rather than by the other persons' actual behaviours, the individuals' choices model is analysed. In conclusion the prominent role of complementarity between choices of individuals is emphasised. The complementarity lets multiple equilibria exist, which justifies the difference in the aggregate behaviour of neighbourhoods with otherwise similar observations (for more details see Durlauf (2004)).

2.4 The average approach

In this study it is assumed that the individual's behaviour is affected by the average choice of neighbours, which is consistent with Brock and Durlauf (2002). They assume the presence of the term Jm_nw_i in agent i's payoff function V_i, where m_n is the expected average choice in the neighbourhood, w_i is the individual i's choice derived from a set of possible behaviours (Ω_i) and J is the behavioral parameter, i.e. J is the coefficient of the term m_nw_i in the agent i's payoff function. The Jm_nw_i also counts for the presence of complementarity, as the second derivative of V_i with respect to m_n and w_i is equal to J,

$$\frac{\partial^2 V_i}{\partial m_n \partial w_i} = J, \qquad m_n = I^{-1}\Sigma_{i=1}^{I} E(w_i|Y_n, X_j \forall j)$$

Thus, an increase in the average crowding of a neighbourhood affects the residential satisfaction of a resident by J times his/her own dwelling's crowding. The effect of average choice of neighbours on the individual's behaviour leads to multiple equilibria derived from the heterogeneity caused by the variation of individuals' characteristics (X_j) across individuals and of neighbourhood characteristics (Y_n) across neighbourhoods. This average choice of neighbours approach justifies how individuals are connected to and affected by one another.

On the other hand, Glaeser, Sacerdote and Scheinkman (1996) assume that an individual is affected by its nearest neighbour rather than its neighbours' average choice. They assume the presence of the term $J_{A(i)}w_iw_{i-1}$ in the agent's payoff function, where w_{i-1} is the behaviour of the neighbour who lives exactly on the left hand side of the individual i. Although this assumption leads to the coverage of all the population of the neighbourhood by connecting neighbours to one another, it does not include a reciprocal relationship between neighbours, i.e. individual i's behaviour does affect individual i-1's behaviour but not vice versa. This assumption limits the heterogeneity to three types of agents (A_i) randomly distributed amongst neighbours, namely, the agent that always chooses independently a crowded dwelling, w_i=1, or a less crowded one, w_i=-1, and the agent that always chooses the same as his/her neighbour, $w_i = w_{i-1}$. This model derives a unique equilibrium, rather than the multiple equilibria in Brock and Durlauf's approach. By considering the variance of the normalised sample average†, it is shown that the model suggested by Glaeser, Sacerdote and Scheinkman has a higher variance of the average observed behaviours compared to the model suggested by Brock and Durlauf.

At local geographic levels, individuals may be affected by small changes in their environment. For instance, if one of the three households who are living in a three storey apartment goes for a vacation at the time of data collection, while the other household has a guest for a while, the best crowding measure would be an aggregate one. In this study that data is collected at a very small geographic level, we choose the average approach on the basis of complementarity.

2.5 Theoretical analysis of the average approach

In the current study, the following payoff function is assumed:

$$RS_i = (1-\alpha)(C_i + C_i^2) + \alpha(C_i - \overline{C_n}) + \delta_i, \delta_i = \omega_i + f(X_i) \quad (4)$$

Where, RS_i is the residential satisfaction of individual i; C_i represents the household crowding of the individual i; $\overline{C_n}$ is the average crowding in individual i's neighbourhood and δ_i is a gauge of the individual's impression of crowding. Thus, δ_i is a function of the individual's characteristics, X_i, and ω_i, which is a constant with a normal distribution, $N(0, \sigma_i^2)$. The impact of the second part of the equation, $(C_i - \overline{C_n})$, on residential satisfaction is gauged by the parameter α, which can be considered as social effects. Thus, $1-\alpha$ is a measure of individual effects, $(C_i + C_i^2)$.

2.6 Individual and household socio-demographic characteristics

Besides the density and crowding variables, socioeconomic variables affect residential satisfaction (Amérigo & Aragonés, 1997; Chapman & Lombard, 2006). For example, Baum, Arthurson, and Rickson (2010) claim that the level of income, the tenure status and the ethnicity of residents within a neighbourhood affect neighbourhood satisfaction. In another study, Dekker, de Vos, Musterd, & van Kempen (2011) claim that housing characteristics do not affect neighbourhood satisfaction (as mentioned in section 1.1, this is in line with Rodgers, 1982). They find that the characteristics of individuals and their opinions about the living environment have a greater effect on neighbourhood satisfaction than the characteristics of the residential environment. People with higher income levels afford more expensive houses and usually have fewer residential problems. Hence household income is a key socioeconomic factor, which may affect satisfaction with housing. It also affects the purchase power of people and, consequently, their tenure status.

As mentioned in some studies, home ownership significantly increases residential satisfaction as it provides more choices for occupants, such as the choice of neighbourhood and house quality (Diaz-Serrano, 2009). However, the extent of the satisfaction improvement depends on people's evaluation of the ownership value, which derives from housing affordability. Another issue about the measured influence of tenure status relates to the behavioural impact of assessing satisfaction after paying for a house. As Dekker et al. (2011) mention, people are not keen to state low satisfaction with a possession

† The distribution of the normalised sample average will be,

$$(2n+1)^{-\frac{1}{2}} \sum w_i \rightarrow wN\left(0, \frac{p(1-p)(2-\pi)}{\pi}\right), \quad where\ p = \frac{p_1}{p_1 + p_2}\ and\ \pi = p_1 + p_2$$

Here agent A is assumed to be distributed in the neighbourhood by the probability of p_A. Consequently, by assuming an increase in the percentage of the type 2 agents, π approaches 0 and the variance approaches infinity.

that they have paid a lot for, while renters are more honest in their assesments as they do not have that ownership feeling to their house. According to Statistics New Zealand (2011), renters are twice as likely to have major problems with their residential environment than owners. Homeownership also affects social capital formation (Roskruge, Grimes, McCann, & Poot, 2013), which leads to a higher life satisfaction (Bjørnskov, 2003).

One of the factors that affects residential satisfaction is the extent to which individuals use their dwelling and neighbourhood environment. People who are more limited to staying within their living environment, such as the elderly, are more likely to have negative attitudes towards their neighbourhood (Dekker et al., 2011; Guest & Wierzbicki, 1999). Education level, as a socio-economic factor, usually leads to a more expanded social network and consequently a higher use of the urban environment. Ethnicity is another important factor in the use of neighbourhood environment. Generally, people with the same ethnicity are more connected to each other. As a result, immigrant groups and ethnic minorities usually live in more concentrated areas and so are more limited to their own neighbourhood (Baum et al., 2010; Mare & Coleman, 2011; Wang & Maani, 2012).

With regard to individuals' characteristics, the effect of household's composition on individuals' satisfaction needs to be considered. For example, the probability of suffering from a small house is higher for a larger household than a smaller one. Consequently, parents without children are more likely to report higher residential satisfaction than those with children, especially since the latter have less mobility if they do not feel satisfied with their place (Brodsky, O'Campo, & Aronson, 1999). On the other hand, some studies emphasise the intermediary role of children in generating social interactions (Guest & Wierzbicki, 1999). Another factor that affects satisfaction is age, which shows a positive correlation with satisfaction levels (see, for example Lu, 1999). This might be a matter of time, as older people have probably lived in a house for a longer time and they have already adapted to probable problems (Dekker et al., 2011).

3 Data and sample

The first data set we will use is the New Zealand General Social Survey (NZGSS) by Statistics New Zealand. This survey is carried out in three series in April 2008, October 2010, and April 2012. The number of the sample population for each wave is approximately 8500, a number which was selected to represent the total population. The data collected by a face-to-face interview was conducted with the respondent by an interviewer using a laptop. Each household was interviewed once and the average interview time per household was 45 minutes. The survey consists of two separate parts, the household questionnaire (3.1.1) and the personal questionnaire (3.1.2).

The other data set to be used is the New Zealand Census 2006 by Statistics New Zealand (SNZ), which is an official count of the population and dwellings in New Zealand. This data set contains data on Mesh-block levels, which is the smallest geographical level in which the data is processed by SNZ. We match the NZGSS with this data set in order to figure out the urban area in which the individuals are located. I will explain the matching process in section 3.2.

3.1.1 The household questionnaire

The first questions of the survey are about members of the household. These questions include sex, age and ethnicity. Based on some eligibility rules, the household members, who are in scope and are available during the interview period, answer these questions. Then the computer selects one of the members to answer the next part, which is the personal questionnaire.

3.1.2 The personal questionnaire

This questionnaire consists of 14 different topic modules to be answered by the randomly selected person. In this study, in addition to the core personal data, satisfaction with living environment, health, skills and abilities are considered. Residential satisfaction was described earlier in 2.1. Health perceptions are derived from a question that asks 'In general, would you say your health is excellent, very good, good, fair or poor?' and skills perceptions are derived from another question asking 'How do you feel about your knowledge, skills and abilities?'. Respondents are questioned about their feeling about their current living environment at the time of the interview and they can choose among five responses, 'very satisfied' to 'very dis-satisfied'. The core personal data are mostly categorical. For example, the household income is measured based on the New Zealand Standard Classification of Income Bands 2009, which has 16 categories.

3.2 Matching the data sets

As table 1 depicts, in order to derive the variables of interest, the New Zealand General Social Survey (Statistics New Zealand, 2009, 2011) and the New Zealand Census of population and dwellings (Statistics New Zealand, 2006a) are matched based on Mesh-block IDs, for which there is data in both data sets. Then the individuals' variables, such as demographics, derived from NZGSS can be used as control variables and the average room density of Mesh-blocks can be derived from the Census to be used in the construction of relative variables of interest.

Table 1- Matching data sets based on Mesh-block IDs

New Zealand General Social Survey (2008, 2010, and 2012)		New Zealand Census 2006[1]
Individuals' characteristics Individual's crowding		Mesh-blocks' average crowding
Mesh-block ID		Mesh-block ID

One may worry about the use of different waves of data as there might be some changes not captured in between. However, since we are not studying a longitudinal change, this is not a source of concern in this study. Also as Meen, Nygaard, and Meen (2013) argue, neighbourhoods' social structures are persistent over long periods such that their relative spatial patterns may not change for decades.

In the neighbourhood level studies, availability of a data set that provides data at small geographic scale plays a prominent role. To this writer's knowledge, no previous study has attempted to use the New Zealand General Social Survey (Statistics New Zealand, 2009, 2011, 2013) matched with New Zealand Census of population and dwellings (Statistics New Zealand, 2006a) to have data on both individuals and neighbourhoods at a very local level. However, Clark and Kim (2012) uses three waves of the Census at neighbourhood level, to study the effect of diversity in the neighbourhood on volunteering, but not integrate the Census data with the GSS unit record data.

In order to take into account the geographic proximity of Mesh-blocks, four geospatial datasets are served, namely, Mesh-blocks' dataset, address points' dataset, roads' and tracks' datasets. After serving the appropriate projection system and editing the datasets, by using network analysis toolbox, a matrix of spatial proximity is derived (for more details see 4.1).

[1] See 'http://www.stats.govt.nz/Census/2006CensusHomePage/MeshblockDataset.aspx' for details of the Mesh-block data, Statistics New Zealand. 2006b. Meshblock Dataset, Vol. 2013.

3.3 Resampling by using replicate weights

Different methods of resampling may serve to increase the precision of estimations using survey designs by deriving more robust standard errors, proportions, odds ratios and regression coefficients. To do so, a random set of observations leave out at each time of estimation. Replication of this leads to the estimation of the bias of a statistic. This method is called Jackknifing. NZGSS provides us replicate weights produced by the delete-a-group jackknife method (Kott, 2001). In the dataset, 100 groups are derived by using primary sampling units (PSUs) randomly sorted into each stratum. This strategy results in 100 replicate samples in each of which one of the groups is omitted and weights are adjusted accordingly. Using these weights in our estimations tends asymptotically to true values.

3.4 The geographic scales

To have a reliable definition of the neighbourhood we should rely on the resident's perception of their neighbourhood boundaries that can be derived from face-to-face interviews (Witten, McCreanor, & Kearns, 2003). A typical definition of neighbourhood consists of a certain number of nearest neighbours. This definition is very similar to the Mesh-block's definition as an area consisting of dwellings that are located close to each other. This is defined by SNZ as the very small neighbourhood, which consists of a few houses located next to each other, with an average population of 50 people. As we assume that the reference group consists of people who live shoulder-to-shoulder with an individual, the MB design suits our purpose well.

In New Zealand's context, the larger neighbourhoods are defined as area units. Most people account themselves as a member of their area units, which is not based on administrative boundaries. Hence, to take perceptions into account, area units may also be considered as a good definition of neighbourhoods. To take a step forward into the perceptional definition of neighbourhoods, we consider the boundaries of territorial authorities (TAs), which emphasise the importance of the community of interest, i.e. people with similar ideas and thoughts about a certain passion are considered to locate in the same territory. This definition, opposed to the MB's, does not take into account proximities, but for common bonds, such as feeling of attachment, or entities, such as a church group.

4 Research design

In order to account for the relative density measures, we estimate the following equation,

$$y_i = \alpha_0 + \alpha_1 . x_i \ + \alpha_2 . x_i^2 \ + \alpha_3 . r_{in} + \beta . (Control\ variables)_i + \varepsilon_i \tag{5}$$

Where, the dependent variable (y_i) is individual i's residential satisfaction. x_i is the objective density measure (RD), x_i^2 is the individual's squared room density and r_{in} measures relative density. Thus, α_1, α_2 and α_3 are the parameters of interest; and ε_i is the error term.

The dependent variable (y_i) follows a Bernoulli distribution, i.e. the dependent variable is a dummy. Thus, the estimated values derived from the right hand side of the equation should be modified such that the outcome is between 0 and 1. To do so, a categorical dependent variable transform function will be served. Two common functions are Logit and Probit. In this study, for the sake of simplicity, a Logit transform function is served.

4.1 Relative measurement

A key distinction of this study is to consider both the raw density measure and a relative measure by considering the ratio of the room density of an individual to the average room density of its neighbourhood, which we call 'crowding ratio'. Besides the crowding ratio the other way of measuring crowding relatively is to state it in terms of a distance from the average crowding of the neighbourhood. This variation can be stated as a ratio of the standard error of the average crowding amongst neighbourhoods to account for the relative magnitude of the variation. In this study, we consider both the ratio and the variation relative measures. We can, alternatively, compare the crowding ratios of observations by taking a decile approach. In this method, the reference group are the symbol of success group. There are a number of characteristics known as the successful people's features, such as wealth and reputation. The most common feature is the level of income. Therefore, we compare the individual's RD with the RD of people with an income at the 90th percentile.

For example, assume that individual 1 lives in a dwelling with a room density equal to 1 ($\frac{People}{Bedroom}$), which is located in neighbourhood A with an average room density of 0.5ppr. Individual 2 with a room density equal to 2ppr lives in neighbourhood B with an average room density of 2ppr. Also assume that the average room density amongst all regions is equal to 1.5ppr. Consequently, the crowding ratio for individual one is equal to 2ppr and for individual two it is equal to 1ppr.

People's subjective evaluations, for example, those derived from the perceived density measure, depend on a range of factors apart from their relative position. Thus, to account for the relative position of people we need a measure that can be gauged objectively and expressed relatively. As discussed in the literature review section, the room density measure is the only variable with such a specification. As we should find the reference group that people compare themselves with, each relative measure should be constructed by considering different potential reference groups.

In figure 1, the territorial authority l (TLA1) is illustrated, in which dots represent the households and lines represent the Mesh-blocks' boundaries. Thus, individual i, represented by the black square, is located in the Mesh-block j, which is one of the MBs in the area unit k. Based on this we can calculate different relative crowding measures.

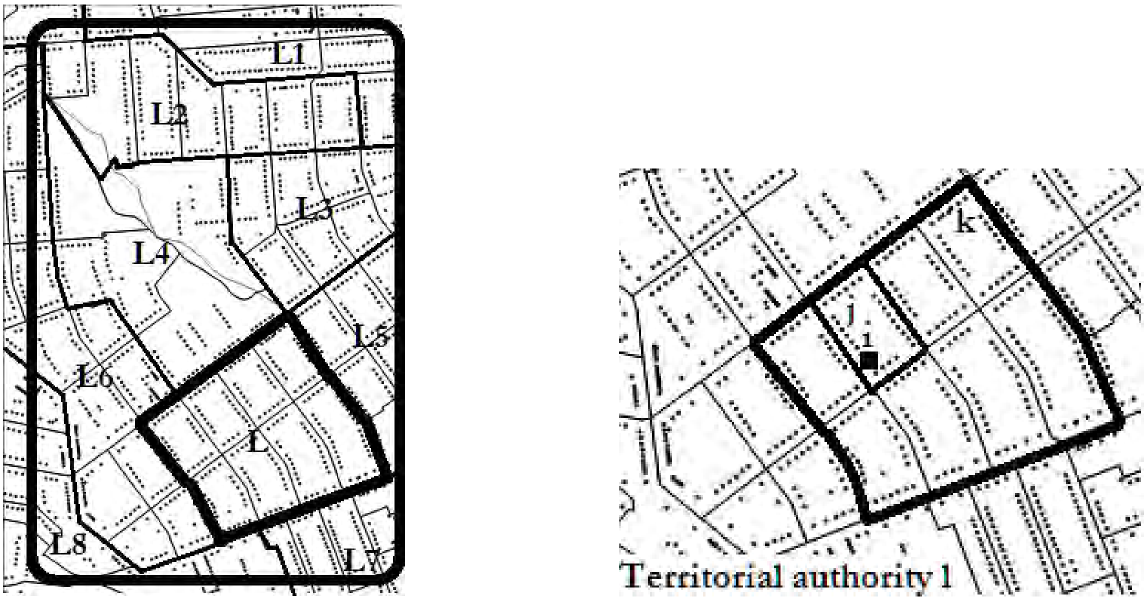


Figure 1. As illustrated on the left hand side, an urban area, demonstrated by the rounded rectangle, may include areas outside of TLAs, such as areas outside of L and L4 TLAs, or may omit parts of the TLAs. For example, parts of the L2 and L8 TLAs are omitted. Map of the territorial authority l is illustrated on the right hand side. It is an illustration of individual i living in MB j, which is located in area unit k.

The ratio of the room density of the observation i to the average of its Mesh-block, MRD_{ij}, is one of the relative measures to be used. Since the number of people living in a MB is small, the relative measure at this level may be very sensitive to small changes in the surrounding environment.

$$MRD_{ij} = \frac{Room\ density\ of\ the\ observation\ i}{Average\ room\ density\ of\ observation\ i's\ Mesh\ block} = \frac{RD_i}{\overline{RD_j}}$$

At a bigger scale, we compare the individual with the average of its area unit, which derives ARD_{ik}. It is often the case that residents have a sense of attachment to their area units. For example, if we ask the individual i about its neighbourhood, s/he is very likely to belong her/himself to the area unit k. Therefore, and also because the area unit is more like an aggregate which is not very sensitive to small changes, the ARD_{ik} seems to be a very sensible relative measure. TRD is the individual's RD as a proportion of the average RD in the territorial authority (TLA).

So far, the relative measures are gauged as a proportion of the average, however, they can also be expressed as variations (VARs), which, as shown in equation (6), expresses the deviation of the variable from its average in the area as a proportion of its standard deviation. The advantage of VARs over the simple proportions is in their dispersion calculation. Therefore, VAR indicates if observation i is an outlier or not. Thus,

$$MVARRD_{ij} = \frac{RD_i - \overline{RD_j}}{Standard\ deviation(RD_j)} \quad (6)$$

The variation value of individual i compared to the area unit k, ARD_{ik}, is calculated in the same way and called $AVARRD_{ik}$.

A reason for a higher residential satisfaction while people live in a crowded dwelling may be living in a less crowded surrounding area. Thus, we should account for the relative density of surrounding areas in the same way that we did for the relative room density of individuals. For example, the area density of Mesh-block j ($MDENS_j$) can be expressed as a ratio of the area density of the area unit k ($ADENS_k$), which derives $MADENS_{jk}$. Similarly, MTDENS and ATDENS are the ratios of the area density of MBs to TLAs and AUs to TLAs. Also, we calculate the variation value of area density variables in the same way that we calculated it for the RD measures. For example, $MVARDENS_{jk}$ is the coefficient of variation of the $MDENS_{jk}$.

To compare the individuals with the symbols of success group as the reference group, we construct the AHRD measure which compares an individual's RD with the average RD of individuals with an income at the 90^{th} percentile in the AU. Similarly, THRD is the ratio of the individuals' RD to the average RD of their TLA's 90^{th} percentile of income. Also, the same approach is taken for income comparisons. Therefore, MIR represents the individual's income level as a ratio of the average income in its neighbourhood.

A complementary approach to promote the relative measurement is to use the Network Spatial analysis to account for walking distance from Mesh-blocks' centroids. This method derives polygons of 5 minutes walking distance around the centroids of mesh-blocks. The overlap of a mesh-block's polygon layer divided by its total intersecting area with other mesh-blocks plus the MB's average crowding/area density value is considered as the reference group's absolute crowding/area density value. This will be used in the construction of the ratio and variation measures. This method takes into account the importance of walking distances in social comparisons. Since we are not aware of the exact location of individuals in the mesh-blocks, the centroid of dwellings' doors is considered as a mesh-block's centre, which helps to decrease the probability of the improper attribution of the relative measures to the people who live closer to the edges of MBs.

To fix ideas, a number of MBs located in an area unit in Auckland are depicted on the left hand side of the figure 2, in which, the lines represent the boundaries of Mesh-blocks. In order to know about the places that an individual may start a walk, we should know about the places of dwellings. On the right hand side of figure 2, depicted dots represent the entrance of dwellings.

Figure 2. Mesh-blocks and doors

After knowing about the starting points, the walking paths should be recognised. People can either walk through tracks, depicted on the very left hand side of the figure 3, or through roads, illustrated in the centre of the figure. Before deriving the walking distance polygons, the start points should be clarified. For the sake of simplicity, a dwelling which locates the most centrally in each MB, is considered as the starting walking point, which is illustrated on the right hand side of the figure 3.

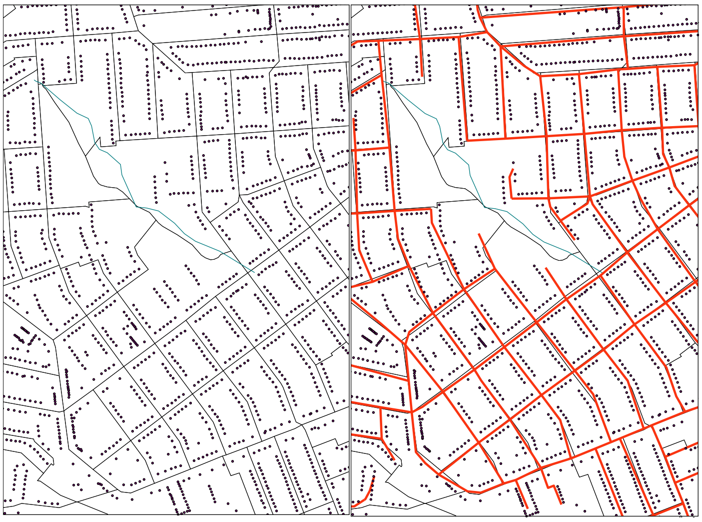


Figure 3. Walking paths and centroids

Derived polygons for a 5 minute walk from the centroid of each mesh block are illustrated on the left hand side of figure 4, in which black dots represent MBs' centroids and shaded polygons indicate the walking polygons. The circled area is illustrated with details on the right hand side of the figure, which ables us to explain the spatial matrix derivation.

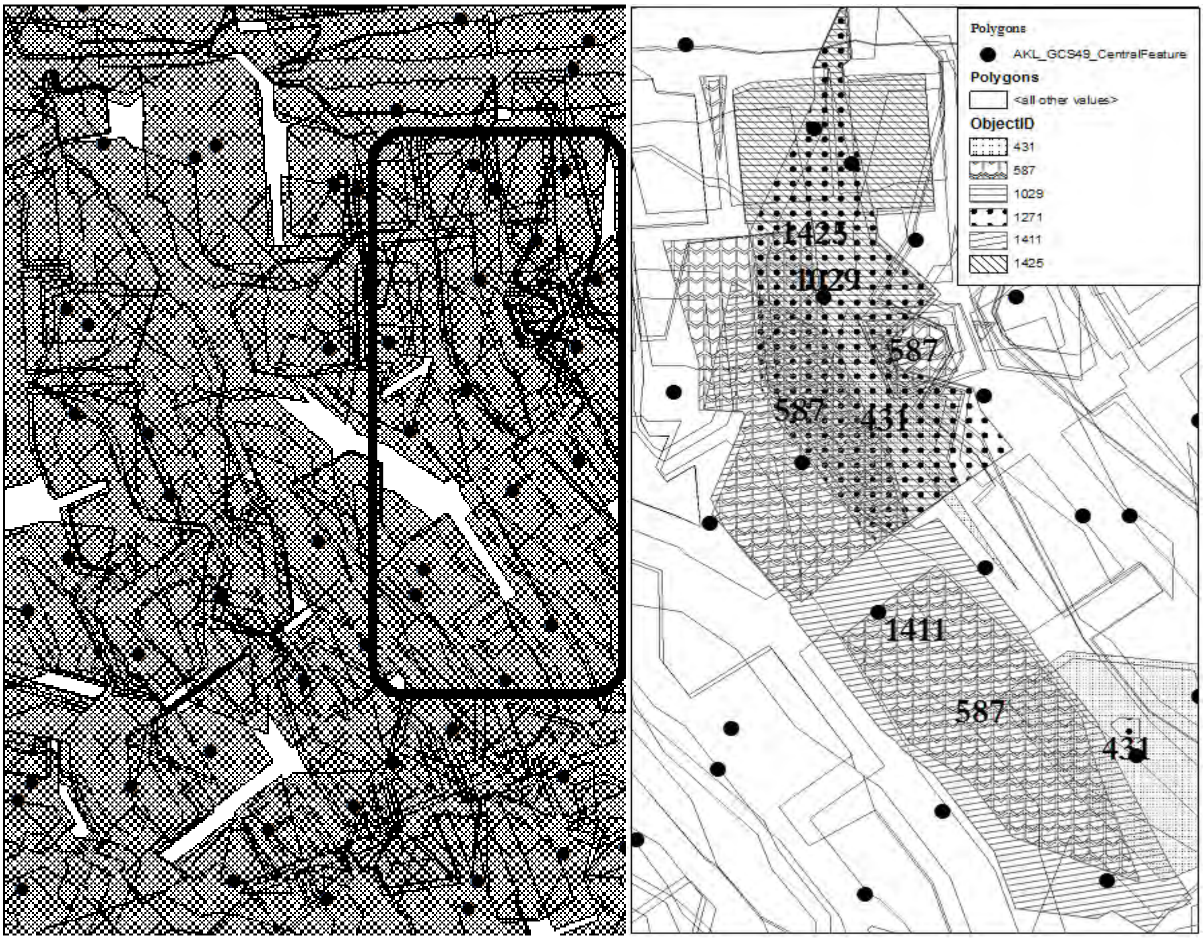


Figure 4. Walking distance polygons.

The walking distance polygon of Mesh-block number 1411[1] has overlapped walking distance polygons of MBs 437, 587, 964, 1029, 1411 and 1425. To derive the geographic weights for MB 1411, we need to calculate the ratio of the intersecting area between 1411 and the other MBs to the total overlapping area. The total overlapping area is equal to 241374 square meters, of which 13227.841 square meters are overlapped Mesh-block number 431. Thus, as it is depicted in the following matrix (equation (7)), the row number 1411 column number 431 of the spatial matrix is equal to 0.054 $(=\frac{13227.841}{241374})$.

	1411	1029	431	587	964	1425
1411	0	0.053	0.054	0.277	0.092	0.049
1029	0.052	0	0.067	0.07	0.118	0.233

(7)

The final weight matrix in our sample is a 740x740 matrix, i.e. it contains the weights for 740 MBs. This matrix is a sparse one, which means that it contains a large proportion of zeros. Almost half of the MBs are not affected by any other MB in terms of walking distance.

We assume that an individual's own MB affects her the most. Therefore, the diagonal of the spatial weight matrix is equal to one. The multiplication of this matrix by the crowding of MBs is our reference group's absolute crowding value, named RDMS, to be used in the construction of a relative measure as a ratio, named MRDS, and a variation, called MVARRDS. The relative crowding measures constructed in this paper are illustrated in appendix ii.

[1] In this example, the Mesh-block IDs are arbitrary.

5 Descriptive statistics

Table 2 contains the descriptive statistics of the variables of interest. Since for the comparisons with the symbols of success we have constructed two variables based on the 90th income percentile, the 10th and 90th percentile statistics are presented in the last two columns of table 2, namely P10 and P90.

Table 2. Geographic units and individual level descriptive statistics.

Descriptive Statistics							
Variable	Categories	Mean	Min	Max	SD	P10	P90
At Individual level							
RD		0.914	0.105	2	0.429	0.333	1.5
PD		0.111	0	1	0.314	0	1
Number of Bedrooms	One	0.055	0	0.694	0.099	0	0.143
	Two	0.188	0	0.953	0.15	0	0.375
	Three	0.439	0	0.933	0.165	0.231	0.65
	Four	0.201	0	0.667	0.129	0.065	0.385
	Five	0.054	0	0.556	0.063	0	0.125
	Six	0.012	0	0.143	0.025	0	0.053
	Seven	0.002	0	0.111	0.011	0	0
	Eight	0.004	0	0.125	0.015	0	0
Household size	One	0.189	0	0.831	0.128	0.065	0.353
	Two	0.295	0	0.667	0.098	0.175	0.417
	Three	0.182	0	0.5	0.073	0.091	0.278
	Four	0.175	0	0.556	0.084	0.077	0.286
	Five	0.084	0	0.333	0.057	0	0.158
	Six	0.04	0	0.333	0.045	0	0.1
	Seven	0.018	0	0.286	0.032	0	0.059
	Eight	0.018	0	0.375	0.036	0	0.063
At Mesh block level							
RDM		1.048	0.5	2.905	0.249	0.819	1.354
RDM_MED		1.009	0.5	2.381	0.247	0.741	1.3
MRD		0.894	0.101	3.105	0.425	0.386	1.479
MVARRD		-0.334	-23.194	7.374	1.498	-1.766	0.857
MHRD		0.975	0.1	8	0.554	0.4	1.5
MHVARRD		-0.192	-9.604	9.604	1.277	-1.394	0.733
DENSM[1]		3598.698	1.847	$0.15*10^{6}$	6670.283	1187.347	4722.079
MADENS		$0.1678*10^{6}$	52897.73	$28.5*10^{6}$	$2.12*10^{6}$	$0.68*10^{6}$	$2.58*10^{6}$
MTDENS		$0.9747*10^{6}$	6643.976	$255.9*10^{6}$	$20.28*10^{6}$	$1.71*10^{6}$	$10.8*10^{6}$
MAVARDENS		$0.051*10^{12}$	3025.882	$21.276*10^{12}$	$0.858*10^{12}$	$0.0012*10^{12}$	$0.01*10^{12}$
MTVARDENS		$0.1367*10^{12}$	8121.835	$57.1079*10^{12}$	$2.30*10^{12}$	$.0033*10^{12}$	$0.053*10^{12}$
RDMS		1.051	0.5	2.905	0.249	0.819	1.367
RDEPSM		1000.749	866	1436	95.064	901	1137
RDEPM		5.565	1	10	2.819	2	9
At Area unit level							
RDA		1.044	0.798	1.921	0.184	0.869	1.289
RDA_MED		0.993	0.724	1.814	0.154	0.845	1.156

[1] In the density calculations, the areas are measured in square kilometres.

ARD	0.887	0.112	2.505	0.41	0.375	1.451
AVARRD	-0.396	-11.408	7.829	1.731	-2.32	1.073
AHRD	0.931	0.111	7.5	0.519	0.379	1.5
AHVARRD	-0.298	-10.492	10.492	1.478	-1.739	0.882
AHRD95	0.927	0.111	7.5	0.519	0.375	1.5
AHVARRD95	-0.313	-10.515	10.515	1.484	-1.805	0.834
DENSA	0.003	0	0.008	0.001	0.001	0.004
ATDENS	6.142	0.025	72.214	8.809	1.531	7.657
ATVARDENS	0.011	0	0.121	0.013	0	0.023
At TLA level						
RDT	1.034	0.889	1.139	0.078	0.918	1.139
RDT_MED	0.98	0.881	1.127	0.086	0.906	1.127
TRD	0.885	0.092	2.249	0.412	0.363	1.463
TVARRD	-0.678	-13.719	15.828	3.805	-5.245	2.539
THRD	0.922	0.101	2.182	0.431	0.364	1.546
THVARRD	-0.419	-16.661	22.175	5.667	-6.433	5.569
DENST	0.001	0	0.002	0	0	0.002

As shown in equation (1), the objective crowding measure, room density, is measured as a ratio of household size. In table 3, RD is tabulated versus the household size. As depicted, amongst one person families RD is mainly between 0.3 and 0.6. The positive correlation between RD and household suggests that a crowded household never provides enough number of bedrooms for its members.

Table 3. Household size versus Room Density (RD).

Household size	Household crowding (RD)					
	0<RD≤ 0.3	0.3<RD≤ 0.6	0.6<RD≤ 0.9	0.9<RD≤ 1.3	1.3<RD≤ 2	2<RD
One person	0.12	0.69	0.00	0.19	0.00	0.00
Two people	0.00	0.24	0.48	0.24	0.00	0.04
Three people	0.00	0.00	0.33	0.53	0.13	0.00
Four people	0.00	0.00	0.14	0.38	0.41	0.07
Five people	0.00	0.00	0.00	0.63	0.37	0.00
Six people	0.00	0.00	0.00	0.28	0.34	0.38
Seven people	0.00	0.00	0.00	0.00	1.00	0.00
Eight people	0.00	0.00	0.00	0.00	0.73	0.27
N	5715					

In table 4, RD is tabulated versus the subjective variable of interest, Percieved Density (PD). Since room density is a ratio and, thus, a continuous measure, it is categorised to 7 groups based on its distribution (Abas, Vanderpyl, Robinson, Le Prou, & Crampton, 2006). As shown, the percentage of people who perceive a small house problem is increasing as the objective crowding measure (RD) increases.

Table 4. Room Density (RD) versus Perceived Density (small house problem).

Room density	PD: Small house problem	
	No	Yes
0 < Room density ≤ 0.3	0.98	0.02
0.3 < Room density ≤ 0.6	0.97	0.03
0.6 < Room density ≤ 0.9	0.97	0.03
0.9 < Room density ≤1.3	0.90	0.10
1.3 < Room density ≤ 2	0.81	0.19
2 < Room density	0.68	0.32
N	5715	

6 Models and results

Based on the discussion in section 4.1, we have 14 relative crowding measures and 6 relative area density measures[1]. To find the model with the highest predictive power for our dependent variable, residential satisfaction, we should account for all combinations of the relative crowding measures and the relative density measures, which derive 84 equations. In addition to the relative measures, we should account for the raw measures. For example, when we consider the relative crowding position of individuals versus the crowding of different reference groups, the raw crowding measure (RD) should be included in the equations. Also, as we have assumed a quadratic form, the squared term (RD^2) is included in all equations. In regard to the relative density measure, the same approach is taken, i.e. if the density of the geographic scale that the individual lives in is compared with the density over a larger geographic scale, the smallest geographic scale's raw density and its squared form are included in the equations. For example, in an equation that includes ATDENS, the density of area unit as a proportion of the density of the TLA that the area unit is located in, the density of AU and its squared form are included.

As shown in equation **(3)**, in addition to the absolute and relative crowding and density measures, we should take into account the control variables. The regression results from the equations presented in appendix ii show that, based on the best fits derived from AIC, AHRD and AHVARRD have the highest predictive power amongst relative crowding measures. Therefore, in an attempt to find the most accurate reference group, we compared the individuals RD with the average RD of their geographic units' 90th percentile of income, which derives 6 new measures of relative crowding, namely MHRD95, AHRD95, THRD95, MHVARRD95, AHVARRD95, THVARRD95.

In all 120 models, the joint significance of the absolute and relative measures is checked on. This includes the joint significance of the variables of RD and its squared form (RD^2); the relative crowding variable of interest, RD and RD^2; the raw density variable of interest and its squared form; the raw density variable of interest and its squared form; and all raw and relative variables of interest together are reported at the bottom of the table. In all cases the absolute and relative measures showed a joint significant effect.

The best-fit model, contains AHVARRD95 and ATVARDENS. The second to fourth best-fit models respectively include AHVARRD95-ATDENS, ARD-TVARDENS and AHVARRD95-MAVARDENS. Based on all the equations, AHVARRD95 and AHRD have the highest predictive power amongst the relative crowding measures. Amongst relative density measures, ATVARDENS and ATDENS are the best predictors for residential satisfaction.

[1] 14 relative crowding measures are MRD, ARD, TRD, MVARRD, AVARRD, TVARRD, MHRD, AHRD, THRD, MHVARRD, AHVARRD, THVARRD, MRDS, MVARRDS. Also, we have 6 relative crowding measures, namely MADENS, MTDENS, ATDENS, MAVARDENS, MTVARDENS, ATVARDENS.

Table 5 illustrates a summary of the results derived from the equations shown in appendix i. Amongst the raw measures, the crowding measure (RD) has a very significant negative effect. The raw density measure (DENS), also, has a very significant negative effect. People's perceptions (PD), also, have a significant negative impact on RS. Including PD in the equations do not affect the significant negative effect of absolute crowding and area density measures. The relative crowding measures (RC) and the relative area density measures (RDENS) do not affect RS significantly.

Table 5. A summary of the results

Category	Result	Significance
Absolute crowding (RD)	Higher absolute crowding level lowers RS	Yes
Relative crowding (RC)	Higher relative crowding does not affect RS	No
Absolute area density (DENS)	Higher absolute density level lowers RS	Yes
Relative area density (RDENS)	Higher relative area density level does not affect RS	No
Perceived density (PD)	Higher PD level affects RS negatively	Yes

7 Conclusion

Relative measures are constructed based on the ratios and variations at different geographic scales, namely Mesh-blocks, Area units and Territorial authorities. In the construction of the relative measures, three reference groups were defined: neighbours at different geographic scales, neighbours who are the symbols of success at different geographic scales and neighbours who are living in a 5 minute walking distance. Neither the relative crowding measures nor the relative population density measures affect residential satisfaction significantly.

We also hypothesised that area density may affect residential satisfaction positively or negatively depending on whether amenity effects of a denser population outweigh greater congestion effects associated with increasing density. The results show that the absolute crowding and absolute area density measures lower residential satisfaction significantly. This effect persists with the presence of Perceived Density (PD) in the models. Also, the presence of relative measures in the equations does not affect the significant negative impact of the absolute measures.

Future research

We have included all relevant variables within the rich data set. However, one may worry about the positive effect of the individuals' preferences on their satisfaction with the crowding of their residential environment, i.e. an individual may be happier with living in a crowded house. To further investigate this plausible Endogeneity issue, we will take a Heckit approach where the selection equation for whether someone lives in a particular area includes exogenous group variables for 'own group' attraction characteristics, such as income, ethnicity and the place of birth. To achieve a greater likelihood of exogeneity, the 'own group' attraction variables will be taken from the last wave of Census, which is Census 2001.

The spatial relative measure constructed in this study does not affect residential satisfaction significantly. This may be caused because of the low variations of this measure. In the current study, the relative spatial crowding measure is constructed based on the spatial weight matrix derived from 5 minute walking distance polygons. Considering a wider range, for example, a 15 minute walking distance, may increase the significance of this relative measure, i.e. people may compare themselves with neighbours living farther than a 5 minute walking distance. Also, in the current study, the spatial approach is only taken at the Mesh-block geographic scale. The significance of the spatial comparisons should be checked at larger geographic units, such as at the Area Units' level.

8 References

Abas, M. A., Vanderpyl, J., Robinson, E., Le Prou, T., & Crampton, P. 2006. Socio-economic deprivation and duration of hospital stay in severe mental disorder. *The British Journal of Psychiatry*, 188(6): 581-582.

Amérigo, M. a., & Aragonés, J. I. 1997. A theoretical and methodological approach to the study of residential satisfaction. *Journal of Environmental Psychology*, 17(1): 47-57.

Atkinson, R., & Kintrea, K. 2001. Disentangling area effects: evidence from deprived and non-deprived neighbourhoods. *Urban studies*, 38(12): 2277-2298.

Barbosa, O., Tratalos, J. A., Armsworth, P. R., Davies, R. G., Fuller, R. A., Johnson, P., & Gaston, K. J. 2007. Who benefits from access to green space? A case study from Sheffield, UK. *Landscape and Urban Planning*, 83(2–3): 187-195.

Baum, S., Arthurson, K., & Rickson, K. 2010. Happy people in mixed-up places: the association between the degree and type of local socioeconomic mix and expressions of neighbourhood satisfaction. *Urban Studies*, 47(3): 467-485.

Bjørnskov, C. 2003. The happy few: Cross–country evidence on social capital and life satisfaction. *Kyklos*, 56(1): 3-16.

Brock, W. A., & Durlauf, S. N. 2002. A multinomial-choice model of neighborhood effects. *American Economic Review*: 298-303.

Brodsky, A. E., O'Campo, P. J., & Aronson, R. E. 1999. PSOC in community context: Multi-level correlates of a measure of psychological sense of community in low-income, urban neighborhoods. *Journal of Community Psychology*, 27(6): 659-679.

Chapman, D. W., & Lombard, J. R. 2006. Determinants of neighborhood satisfaction in fee-based gated and nongated communities. *Urban Affairs Review*, 41(6): 769-799.

Churchman, A. 1999. Disentangling the concept of density. *Journal of Planning Literature*, 13(4): 389-411.

Clark, A. E. 2012. Happiness, habits and high rank: Comparisons in economic and social life: SOEPpapers on multidisciplinary panel data research.

Clark, A. E., Westergård ‐ Nielsen, N., & Kristensen, N. 2009. Economic satisfaction and income rank in small neighbourhoods. *Journal of the European Economic Association*, 7(2 ‐ 3): 519-527.

Clark, J., & Kim, B. 2012. The effect of neighbourhood diversity on volunteering: Evidence from New Zealand. *BE Journal of Economic Analysis and Policy*, 12(1).

Dekker, K., de Vos, S., Musterd, S., & van Kempen, R. 2011. Residential Satisfaction in Housing Estates in European Cities: A Multi-level Research Approach. *Housing Studies*, 26(04): 479-499.

Diaz-Serrano, L. 2009. Disentangling the housing satisfaction puzzle: Does homeownership really matter? *Journal of Economic Psychology*, 30(5): 745-755.

Durlauf, S. N. 2004. Chapter 50 Neighborhood effects. In J. V. Henderson, & T. Jacques-François (Eds.), *Handbook of Regional and Urban Economics*, Vol. Volume 4: 2173-2242: Elsevier.

Ellaway, A., Macintyre, S., & Bonnefoy, X. 2005. Graffiti, greenery, and obesity in adults: secondary analysis of European cross sectional survey. *BMJ: British Medical Journal*, 331(7517): 611.

Erdős, P., & Rényi, A. 1960. On the evolution of random graphs. *Magyar Tud. Akad. Mat. Kutató Int. Közl*, 5: 17-61.

Fabling, R., Grimes, A., & Stevens, P. 2012. The relatives are fine: use of qualitative firm data in economic analysis. *Applied Economics Letters*, 19(7): 615-618.

Galster, G., & Hedman, L. 2013. Measuring Neighbourhood Effects Non-experimentally: How Much Do Alternative Methods Matter? *Housing Studies*, 28(3): 473-498.

Glaeser, E. L., Sacerdote, B., & Scheinkman, J. A. 1996. Crime and social interactions. *Quarterly Journal of Economics*, 111(2): 507-548.

Guest, A. M., & Wierzbicki, S. K. 1999. Social Ties at the Neighborhood Level Two Decades of GSS Evidence. *Urban Affairs Review*, 35(1): 92-111.

Halpern, D. 2005. Social Capital. Malden: USA: Polity Press.

Helliwell, J. F. 2003. How's life? Combining individual and national variables to explain subjective well-being. *Economic Modelling*, 20(2): 331-360.

Kingdon, G. G., & Knight, J. 2007. Community, comparisons and subjective well-being in a divided society. *Journal of Economic Behavior & Organization*, 64(1): 69-90.

Knight, J., & Gunatilaka, R. 2010. Great Expectations? The Subjective Well-being of Rural–Urban Migrants in China. *World Development*, 38(1): 113-124.
Kott, P. S. 2001. The delete-a-group jackknife. *Journal of Official Statistics*, 17(4): 521-526.
Larwood, L., & Whittaker, W. 1977. Managerial myopia: Self-serving biases in organizational planning. *Journal of applied psychology*, 62(2): 194.
Lu, M. 1999. Determinants of Residential Satisfaction: Ordered Logit vs. Regression Models. *Growth and Change*, 30(2): 264-287.
Manski, C. F. 1993. Identification of endogenous social effects: The reflection problem. *The review of economic studies*, 60(3): 531-542.
Manski, C. F. 2000. Economic Analysis of Social Interactions. *National Bureau of Economic Research Working Paper Series*, No. 7580.
Mare, D., & Coleman, A. 2011. Estimating the determinants of population location in Auckland.
Meen, G., Nygaard, C., & Meen, J. 2013. The Causes of Long-Term Neighbourhood Change, *Understanding Neighbourhood Dynamics*: 43-62: Springer.
Morrison, P. S. 2011. Local expressions of subjective well-being: The New Zealand experience. *Regional Studies*, 45(8): 1039-1058.
Palmer, E. M. 1985. *Graphical evolution*: Wiley.
Pearce, J., & Dorling, D. 2006. Increasing geographical inequalities in health in New Zealand, 1980–2001. *International Journal of Epidemiology*, 35(3): 597-603.
Rodgers, W. 1982. Density, crowding, and satisfaction with the residential environment. *Social Indicators Research*, 10(1): 75-102.
Roskruge, M., Grimes, A., McCann, P., & Poot, J. 2013. Homeownership, Social Capital and satisfaction with Local Government. *Urban studies, forthcoming*.
Shaw, M. 1999. *The widening gap: health inequalities and policy in Britain*: The Policy Press.
Singh, G. K., & Siahpush, M. 2006. Widening socioeconomic inequalities in US life expectancy, 1980–2000. *International Journal of Epidemiology*, 35(4): 969-979.
Statistics New Zealand. 2006a. Census data. Wellington.
Statistics New Zealand. 2006b. Meshblock Dataset, Vol. 2013.
Statistics New Zealand. 2009. New Zealand general social survey: 2008. Wellington.
Statistics New Zealand. 2011. New Zealand General Social Survey 2010. *Wellington: Statistics New Zealand. http: //www. stats. govt. nz/browse_for_stats/people_and_communities/Households/nzgss_HOTP2008/Tables. aspx*.
Statistics New Zealand. 2013. New Zealand general social survey: 2012. *Wellington*.
Torshizian, E., & Grimes, A. 2014. Is residential satisfaction a matter of crowding perception? *Mimeo*.
Wang, X., & Maani, S. 2012. Assimilation, ethnic capital and earnings of immigrants in New Zealand: a spatial approach, *International Conference: Futures for the metropolis: Pathways for development in Auckland and beyond*, Vol. Session 7. Massey University, Auckland.
Witten, K., McCreanor, T., & Kearns, R. 2003. The place of neighbourhood in social cohesion: Insights from Massey, West Auckland. *Urban Policy and Research*, 21(4): 321-338.
Yoshikawa, H., & Ohtaka, F. 1989. An analysis of female labor supply, housing demand and the saving rate in Japan. *European Economic Review*, 33(5): 997-1023.

Appendix I. Descriptive statistics of control variables[1]

All variables in table 6, descriptive statistics, are dummy variables. For example, 'Gender' is a binary variable with 0 for females and 1 for males. The mean of this variable is equal to 0.485 indicating that 48.5 percent of respondents are male and the rest are female. On the very right hand side column, the equality of the mean of each variable between three waves of data, namely 2008, 2010 and 2012 is tested. As it is depicted, the significance level less than 0.001 for the 'Age' variable statistically violates the null hypothesis that there is no change in the mean of this variable between 2008 and 2010, i.e. it indicates that the percentage of people distributed in different age groups changes amongst these three waves of data.

To avoid a very long list of variables in the regression tables, some of the variables with similar effects have been recategorised. In the 'Group' column of table 6, the group of each category is shown amongst different variables. For example, for 'Homeownership status', group 'i' includes categories 'Owned, not defined', 'Owned, mortgage' and 'Owned, no mortgage', and so on. The criteria for grouping some categories are first the diversity of the category, e.g. MELAA ethnicity, consisting of Middle Eastern, Latin American and African ethnicities, is a highly diverse category, thus it is grouped with 'Other', and second the results derived from different categories, i.e. two categories are grouped if they show very similar patterns in regression models.

In a comparison between three waves, for almost all residential issues, a lower fraction of respondents report problems with their neighbourhoods in 2010. For most housing problems, however, this difference is not statistically significant at the 1 percent level. Three main variables in this table are five-level Likert scale based, namely, health perception, ability perception and residential satisfaction. Health and ability perception variables are of interest here to address the potential 'over-optimism' bias as we will discuss in the next section.

Table 6. Descriptive statistics

Variables	Description	Group	Mean	Mean difference significance
Gender	0 = "female", 1 = "male"	-	0.484	0.591
Partner	0 = "Non-partnered", 1 = "Partnered"	-	0.597	0.413
Age	= 15-19	i	0.093	0.691
	= 20-24	ii	0.103	
	= 25-29	iii	0.095	
	= 30-34	iii	0.089	
	= 35-39	iv	0.092	
	= 40-44	iv	0.097	
	= 45-49	iv	0.094	

[1] As the research is on going, the descriptive statistics presented in this section are not limited to the sample population included in the estimations, i.e. this section represents the descriptive statistics for the sample population of the three waves of NZGSS.

	= 50-54	iv	0.078	
	= 55-59	v	0.068	
	= 60-64	vi	0.056	
	= 65-69	vii	0.046	
	= 70-74	viii	0.034	
	= 75-79	ix	0.024	
	= 80-84	ix	0.019	
	= >85	i	0.014	
Length of living in NZ	< 4 years	i	0.103	<0.001
	= 4-10 years	ii	0.139	
	= 10-25 years	iii	0.107	
	>25 years	iv	0.651	
Ethnicity	European	i	0.607	0.221
	Maori	ii	0.044	
	European/Maori	ii	0.079	
	Pacific	iii	0.188	
	Asian	iv	0.028	
	MELAA	v	0.037	
	Other	v	0.026	
Education	= No qualification	i	0.136	0.237
	= Certificates	ii	0.479	
	= Degree	iii	0.386	
Personal income‡	=Zero	i	0.094	0.111
	=$1-$5,000	ii	0.059	
	=$5,001 - $10,000	iii	0.049	
	=$10,001 - $15,000	iii	0.083	

‡ Strictly speaking, we should inflation adjust the thresholds for personal and household income, but this is not a practical approach owing to the questionnaire design, i.e. due to the categorical design of the income variable, we are not aware of individuals' absolute value of income. CPI inflation from the quarter one of 2008 to the second quarter of 2012 was approximately 12%.

	=$15,001 - $20,000	iii	0.09	
	=$20,001 - $25,000	iii	0.065	
	=$25,001 - $30,000	iii	0.057	
	=$30,001 - $35,000	iii	0.053	
	=$35,001 - $40,000	iii	0.056	
	=$40,001 - $45,000	iii	0.083	
	=$45,001 - $50,000	iii	0.068	
	=$50,001 - $70,000	iv	0.086	
	=$70,001 - $100,000	v	0.083	
	=$100,001 - $150,000	v	0.047	
	=$150,001 or more	vi	0.026	
Household income	=Zero	i	0.005	0.046
	=$1-$5,000	ii	0.003	
	=$5,001 - $10,000	iii	0.006	
	=$10,001 - $15,000	iii	0.018	
	=$15,001 - $20,000	iii	0.029	
	=$20,001 - $25,000	iii	0.026	
	=$25,001 - $30,000	iii	0.037	
	=$30,001 - $35,000	iii	0.031	
	=$35,001 - $40,000	iii	0.032	
	=$40,001 - $45,000	iii	0.058	
	=$45,001 - $50,000	iii	0.058	
	=$50,001 - $70,000	iv	0.093	
	=$70,001 - $100,000	v	0.189	
	=$100,001 - $150,000	v	0.218	
	=$150,001 or more	vi	0.196	
Household size	= One person	i	0.096	0.557
	= Two people	ii	0.258	

	= Three people	iii	0.208	
	= Four people	iv	0.241	
	= Five people	v	0.117	
	= Six people	vi	0.052	
	= Seven people	vii	0.017	
	= Eight people	viii	0.011	
Health perception	= Very dissatisfied	i	0.021	0.033
	= Dissatisfied	ii	0.092	
	= No feeling either way	iii	0.243	
	= Satisfied	iv	0.372	
	= Very satisfied	v	0.271	
Ability perception (includes individual's feeling about his/her knowledge, skills and abilities)	= Very dissatisfied	i	0.002	0.011
	= Dissatisfied	ii	0.042	
	= No feeling either way	iii	0.074	
	= Satisfied	iv	0.631	
	= Very satisfied	v	0.25	
Residential Satisfaction	= Very dissatisfied	i	0.007	0.398
	= Dissatisfied	ii	0.066	
	= No feeling either way	iii	0.068	
	= Satisfied	iv	0.492	
	= Very satisfied	v	0.367	
Urban area§	= Main urban	i	0.942	0.327
	= Secondary urban	ii	0.017	
	= Minor urban	iii	0.012	
	= Rural	iv	0.029	
Home ownership status	= Owned, not defined	i	0.001	0.175

§ The definition is based on Census 1996. Based on this, definition of urban area types differ based on how strong their economic ties are, how active they are from cultural and recreational point of view, how well they offer services to businesses, how easy it is to access their transportation network and their prospective development.

	= Owned, mortgage	i		0.336		
	= Owned, no mortgage	i		0.179		
	= Not owned, not defined	ii		0.001		
	= Not owned, rent	ii		0.313		
	= Not owned, no rent	ii		0.014		
	= Family trust, not defined	iii		0.002		
	= Family trust, mortgage	iii		0.08		
	= Family trust, no mortgage	iii		0.073		
			2008	2010	2012	
Small house perception	Being too small is a major problem with the person's house/flat? 0 = “No”, 1 = “Yes”		0.112	0.104	0.101	0.696
Bad street access	Being hard to get to from the street is a major problem with the person's house/flat? 0 = “No”, 1 = “Yes”		0.023	0.024	0.011	0.037
Poor condition	Being in poor condition is a major problem with the person's house/flat? 0 = “No”, 1 = “Yes”		0.068	0.052	0.057	0.292
Damp dwelling	Being damp is a major problem with the person's house/flat? 0 = “No”, 1 = “Yes”		0.098	0.109	0.105	0.716
Difficult to heat	Being too cold, or difficult to heat/keep warm is a major problem with the person's house/flat? 0 = “No”, 1 = “Yes”		0.143	0.144	0.151	0.85
Having pests	Having pests such as mice or insects is a major problem with the person's house/flat? 0 = “No”, 1 = “Yes”		0.065	0.066	0.053	0.316
Expensive house	Being too expensive is a major problem with the person's house/flat? 0 = “No”, 1 = “Yes”		0.082	0.064	0.073	0.167
Far from work	Being too far from work is a major problem with the person's street/neighbourhood? 0 = “No”, 1 = “Yes”		0.067	0.049	0.03	<0.001
Far from facilities	Being too far from other things that he/she wants to get to is a major problem with the person's street/neighbourhood? 0 = “No”, 1 = “Yes”		0.041	0.037	0.018	0.02
Unsafe neighbourhood	Being unsafe is a major problem with the person's street/neighbourhood? 0 = “No”, 1 = “Yes”		0.052	0.032	0.035	0.061
Noise and vibration	Noise or vibration is a major problem with the person's street/neighbourhood? 0 = “No”, 1 = “Yes”		0.14	0.123	0.102	0.045
Air pollution	Air pollution from traffic fumes, industry or other smoke is a major problem with the person's street/neighbourhood? 0 = “No”, 1 = “Yes”		0.052	0.034	0.029	0.013

Household crowding (Canadian index)	= One bedroom needed	i	0.003	0.073	0.081	<0.001
	= No bedrooms needed	ii	0.135	0.264	0.242	
	= One bedroom spare	iii	0.374	0.343	0.329	
	= Two or more bedrooms spare	iv	0.488	0.32	0.347	
Free time (Individual's feeling about having enough free time)	= Too much free time	i		0.421		0.01
	= The right amount of free time	ii		0.479		
	= Not enough free time	iii		0.1		
Socialising (Frequency of meeting friends)	= Every day	i		0.087		0.311
	= Around 3-6 times a week	ii		0.149		
	= Around 1-2 times a week	ii		0.373		
	= Around once a fortnight	iii		0.213		
	= At least once in the last four weeks	iv		0.178		
Local political involvement	0 = 'No', 1 = 'Yes'	-		0.382		0.583
Recycling (How much does the household recycle)	= None	i		0.011		0.478
	= A little	i		0.02		
	= Some	ii		0.11		
	= Most	iii		0.556		
	= All	iv		0.303		
Council services (Individual's feeling about the quality of council services)	= Very dissatisfied	i		0.025		<0.001
	= Dissatisfied	ii		0.099		
	= No feeling either way	iii		0.138		
	= Satisfied	iv		0.603		
	= Very satisfied	v		0.135		
Green space access (Access to local green spaces including bushes, forests, nature reserves)	= Never want or need to go	i		0.018		0.01
	= None of them	i		0.01		
	= A few of them	i		0.056		
	= Some of them	i		0.152		
	= Most of them	ii		0.437		

	= All of them	iii	0.328	
Green space state	= Not been to	i	0.001	0.042
	= Very dissatisfied	ii	0.002	
	= Dissatisfied	iii	0.03	
	= No feeling either way	iv	0.092	
	= Satisfied	v	0.644	
	= Very satisfied	v	0.221	
Coastline access (Access to local lakes, rivers, harbours and oceans)	= Never want or need to go	i	0.015	0.02
	= None of them	i	0.017	
	= A few of them	i	0.055	
	= Some of them	i	0.15	
	= Most of them	ii	0.42	
	= All of them	iii	0.343	
Coastline state (Household's feeling about the state of coastlines)	= Not been to	i	0.01	0.131
	= Very dissatisfied	ii	0.007	
	= Dissatisfied	iii	0.081	
	= No feeling either way	iv	0.113	
	= Satisfied	iv	0.632	
	= Very satisfied	v	0.157	
Water use (How often does the household try to minimise water use?)	= None of the time	i	0.085	0.336
	= A little of the time	ii	0.107	
	= Some of the time	iii	0.267	
	= Most of the time	iv	0.398	
	= All of the time	iv	0.143	
Energy use (How often does the household try to minimise energy use?)	= None of the time	i	0.023	0.056
	= A little of the time	ii	0.086	
	= Some of the time	ii	0.299	
	= Most of the time	iii	0.466	

	= All of the time	iii	0.126	
Facilities access (including shops, schools, post shops, libraries and medical services)	= Never want or need to go to any of them	i	0.003	0.634
	= None of them	ii	0.006	
	= A few of them	ii	0.025	
	= Some of them	iii	0.058	
	= Most of them	iii	0.302	
	= All of them	iv	0.606	
Year	= 2008	-	0.339	
	= 2010	-	0.332	
	= 2012	-	0.329	
Observations	5715			

Room density, which is one of the variables of interest, is derived from dividing the household size variable by the number of bedrooms in dwelling. As illustrated in table 7, room density takes values between minimum 0.2 and maximum 8. The mean difference amongst years is not significant and the overall mean is equal to 0.98 deriving from 25693 observations. As depicted on the left hand side of figure 5, 54 percent of observations have a room density less than 0.8, 25 percent equal to 1 and 25.12 percent greater than 1 and less than 2.1. To derive a more reliable measure we drop the outliers who have reported a room density between 2.1 and 8. This consists of only 101 observations, i.e. less than 1.8 percent of the sample population. The kernel density by imposing this restriction on the room density variable is illustrated on the right hand side of the figure 5.

Table 7. Room density summary statistics.

	Observations	Mean			P_value	Min	Max	Std error
		2008	2010	2012				
Unrestricted Room density	5816	1.041	1.081	1.041	0.158	0.2	7	0
Retricted Room density	5715	1.006	1.038	1.006	0.171	0.2	2	0

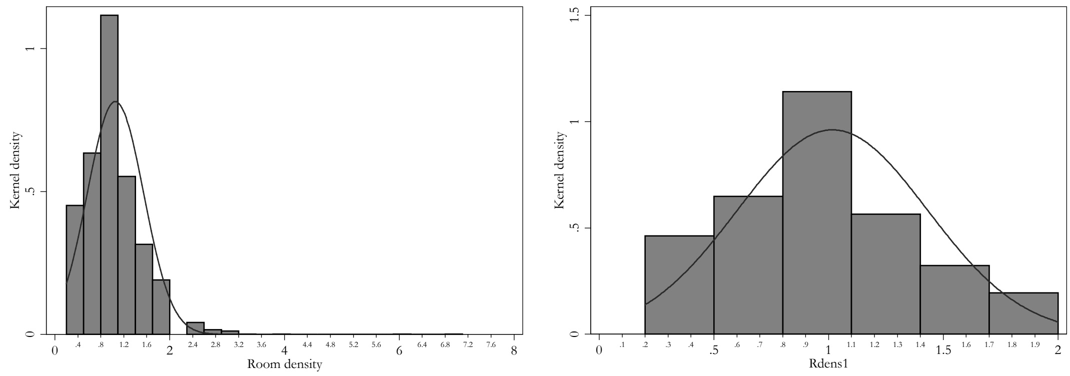


Figure 5. Room density histogram. On the left hand side, the kernel density is illustrated before omitting the outliers. The figure on the right hand side depicts the kernel density after restricting the variable to 98.2 percent of the sampling population. The horizontal axis is the number of people per bedroom.

In figure 6, the proportion of various housing problems amongst each satisfaction category is illustrated. The most important problem amongst all satisfaction groups is the problem with heating up the dwelling. Not enough space, poor condition and dampness of the dwelling are the second to fourth most common problems amongst almost all satisfaction groups, except for the very satisfied group who have stated having pests in the house as the second most frequent problem. In regard to how challenging each housing problem is for different satisfaction groups, the more satisfied people report less problem with their dwellings.

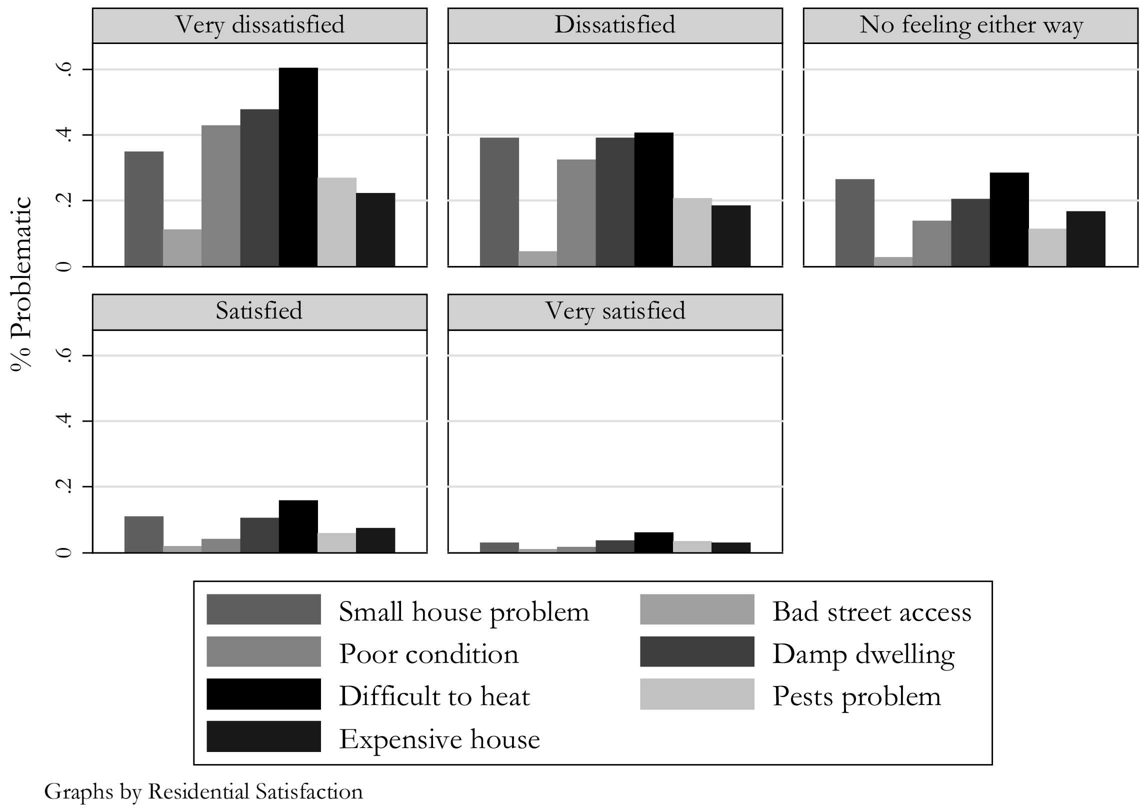


Figure 6. The proportion of various problems with dwellings amongst different residential satisfaction levels.

Figure 7 illustrates the proportion of various problems with neighbourhoods amongst different residential satisfaction levels, where having noise or vibration is reported as the most important problem. For more dissatisfied people, the safety of the neighbourhood is the second most prevalent problem, while for the more satisfied people, the distance to their workplace is the second and safety is the least problematic issue. The neighbourhood challenges, similar to housing ones, have a negative correlation with residential satisfaction. In order to control for the variations in residential satisfaction that have been caused by the residential environment's problems, all of the problems are included as dummies in the next chapters' equations.

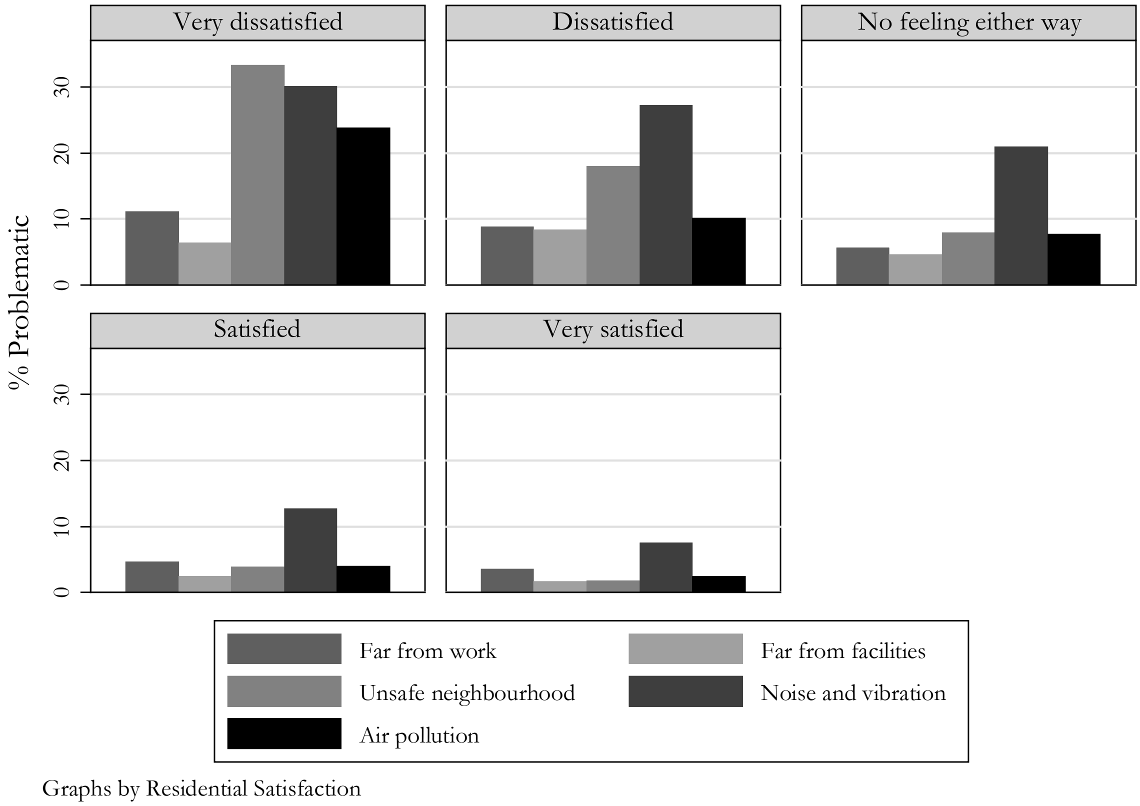
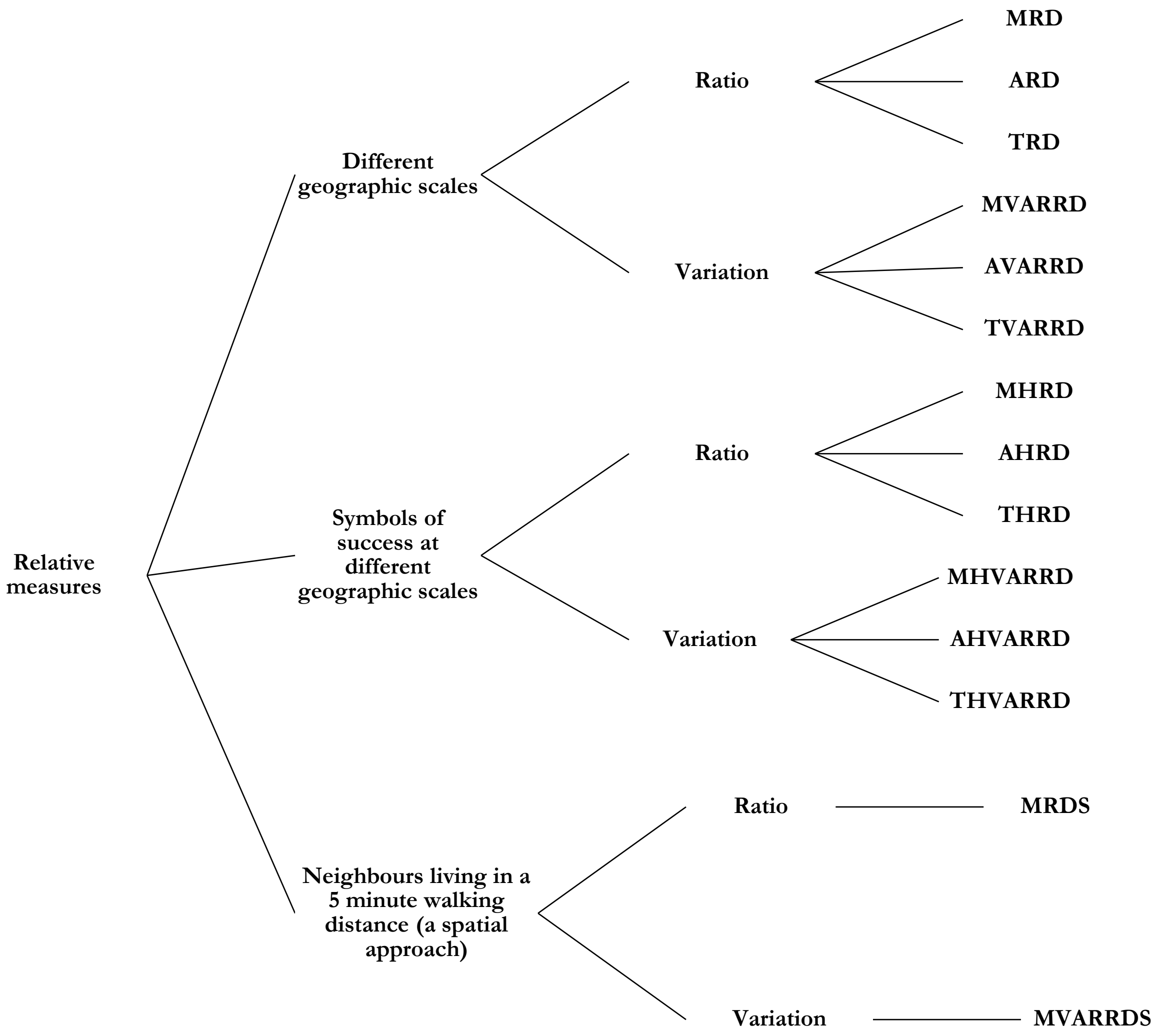


Figure 7. The proportion of various problems with neighbourhoods amongst different residential satisfaction levels.

Appendix II. Relative crowding measures

The second nodes from the left hand side represent the reference group considered in the construction of the relative crowding measure. The third nodes from the left hand side illustrate the method which is used in the construction of the measures. The final nodes on the right hand side, contain the name of the measure at three levels: Mesh-block, if the name starts with 'M'; Area unit, if the name starts with 'A'; and Territorial Authority, if the name starts with 'T'.



Appendix III. Models derived from the combinations of relative crowding and density measures

In the following table, the combinations of relative crowding measures versus the relative density measures are presented. In the main equations presented in the section 6, control variables are added to these equations.

Table 8. Combinations of crowding and density measures.

Models	Relative RD	Relative Density	Raw and relative crowding and density measures included in each model
1	MRD	MADENS	RD, RD^2, MRD, DENSM, $DENSM^2$, MADENS
2		MTDENS	RD, RD^2, MRD, DENSM, $DENSM^2$, MTDENS
3		ATDENS	RD, RD^2, MRD, DENSA, $DENSA^2$, ATDENS
4		MAVARDENS	RD, RD^2, MRD, DENSM, $DENSM^2$, MAVARDENS,
5		MTVARDENS	RD, RD^2, MRD, DENSM, $DENSM^2$, MTVARDENS
6		ATVARDENS	RD, RD^2, MRD, DENSA, $DENSA^2$, ATVARDENS
7	ARD	MADENS	RD, RD^2, ARD, DENSM, $DENSM^2$, MADENS
8		MTDENS	RD, RD^2, ARD, DENSM, $DENSM^2$, MTDENS
9		ATDENS	RD, RD^2, ARD, DENSA, $DENSA^2$, ATDENS
10		MAVARDENS	RD, RD^2, ARD, DENSM, $DENSM^2$, MAVARDENS
11		MTVARDENS	RD, RD^2, ARD, DENSM, $DENSM^2$, MTVARDENS
12		ATVARDENS	RD, RD^2, ARD, DENSA, $DENSA^2$, ATVARDENS
13	TRD	MADENS	RD, RD^2, TRD, DENSM, $DENSM^2$, MADENS
14		MTDENS	RD, RD^2, TRD, DENSM, $DENSM^2$, MTDENS
15		ATDENS	RD, RD^2, TRD, DENSA, $DENSA^2$, ATDENS
16		MAVARDENS	RD, RD^2, TRD, DENSM, $DENSM^2$, MAVARDENS
17		MTVARDENS	RD, RD^2, TRD, DENSM, $DENSM^2$, MTVARDENS
18		ATVARDENS	RD, RD^2, TRD, DENSA, $DENSA^2$, ATVARDENS
19	MVARRD	MADENS	RD, RD^2, MVARRD, DENSM, $DENSM^2$, MADENS
20		MTDENS	RD, RD^2, MVARRD, DENSM, $DENSM^2$, MTDENS
21		ATDENS	RD, RD^2, MVARRD, DENSA, $DENSA^2$, ATDENS
22		MAVARDENS	RD, RD^2, MVARRD, DENSM, $DENSM^2$, MAVARDENS
23		MTVARDENS	RD, RD^2, MVARRD, DENSM, $DENSM^2$, MTVARDENS
24		ATVARDENS	RD, RD^2, MVARRD, DENSA, $DENSA^2$, ATVARDENS
25	AVARRD	MADENS	RD, RD^2, AVARRD, DENSM, $DENSM^2$, MADENS
26		MTDENS	RD, RD^2, AVARRD, DENSM, $DENSM^2$, MTDENS
27		ATDENS	RD, RD^2, AVARRD, DENSA, $DENSA^2$, ATDENS
28		MAVARDENS	RD, RD^2, AVARRD, DENSM, $DENSM^2$, MAVARDENS
29		MTVARDENS	RD, RD^2, AVARRD, DENSM, $DENSM^2$, MTVARDENS
30		ATVARDENS	RD, RD^2, AVARRD, DENSA, $DENSA^2$, ATVARDENS
31	TVARRD	MADENS	RD, RD^2, TVARRD, DENSM, $DENSM^2$, MADENS
32		MTDENS	RD, RD^2, TVARRD, DENSM, DENSM2, MTDENS
33		ATDENS	RD, RD^2, TVARRD, DENSA, $DENSA^2$, ATDENS

34		MAVARDENS	RD, RD^2, TVARRD, DENSM, $DENSM^2$, MAVARDENS
35		MTVARDENS	RD, RD^2, TVARRD, DENSM, $DENSM^2$, MTVARDENS
36		ATVARDENS	RD, RD^2, TVARRD, DENSA, $DENSA^2$, ATVARDENS
37	MHRD	MADENS	RD, RD^2, MHRD, DENSM, $DENSM^2$, MADENS
38		MTDENS	RD, RD^2, MHRD, DENSM, $DENSM^2$, MTDENS
39		ATDENS	RD, RD^2, MHRD, DENSA, $DENSA^2$, ATDENS
40		MAVARDENS	RD, RD^2, MHRD, DENSM, $DENSM^2$, MAVARDENS
41		MTVARDENS	RD, RD^2, MHRD, DENSM, $DENSM^2$, MTVARDENS
42		ATVARDENS	RD, RD^2, MHRD, DENSA, $DENSA^2$, ATVARDEN
43	AHRD	MADENS	RD, RD^2, AHRD, DENSM, $DENSM^2$, MADENS
44		MTDENS	RD, RD^2, AHRD, DENSM, $DENSM^2$, MTDENS
45		ATDENS	RD, RD^2, AHRD, DENSA, $DENSA^2$, ATDENS
46		MAVARDENS	RD, RD^2, AHRD, DENSM, $DENSM^2$, MAVARDENS
47		MTVARDENS	RD, RD^2, AHRD, DENSM, $DENSM^2$, MTVARDENS
48		ATVARDENS	RD, RD^2, AHRD, DENSA, $DENSA^2$, ATVARDENS
49	THRD	MADENS	RD, RD^2, THRD, DENSM, $DENSM^2$, MADENS
50		MTDENS	RD, RD^2, THRD, DENSM, $DENSM^2$, MTDENS
51		ATDENS	RD, RD^2, THRD, DENSA, $DENSA^2$, ATDENS
52		MAVARDENS	RD, RD^2, THRD, DENSM, $DENSM^2$, MAVARDENS
53		MTVARDENS	RD, RD^2, THRD, DENSM, $DENSM^2$, MTVARDENS
54		ATVARDENS	RD, RD^2, THRD, DENSA, $DENSA^2$, ATVARDENS