Mobility and urban quality of life: a comparison of the hedonic pricing and subjective well-being methods

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Abstract

There is no consensus about the relation between urban scale and quality of life. We compare quality of life in Oslo and the rest of Norway using two commonly employed methods to measure geographic variation in quality of life - hedonic pricing based on the Rosen-Roback model and analysis of subjective well-being. Since the hedonic pricing approach assumes that households are perfectly mobile, we have divided the population into mobility quartiles. The methods arrive at the same conclusion for the most mobile population group – quality of life is higher in Oslo – but different conclusions for other mobility groups.

Keywords: Quality of life, cities, mobility, hedonic pricing, place satisfaction

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Introduction

Urban scholars distinguish between two types of local amenities: producer amenities that affect firm productivity and consumer amenities that affect quality of life of households (Roback, 1982). There is consensus that firm productivity is higher in cities than in rural areas (Combes and Gobillion, 2015; De la Roca and Puga, 2017). Concerning the relationship between quality of life and urban scale, Okulicz-Kozaryn and co-authors argue that cities possess low quality of life because of social isolation, lack of cohesion, segregation, poverty, crime, pollution, crowding and noise (Berry and Okulicz-Kozaryn, 2009; Okulicz-Kozaryn, 2015, 2017; Okulicz-Kozaryn and Mazelis, 2018; Okulicz-Kozaryn and Valente, 2018). On the other hand, Edward Glaeser and co-authors emphasize the positive aspects of city living: a rich variety of services and consumer goods, low transportation costs, architectural beauty, high-quality public services and cultural diversity (Glaeser et al., 2001; Glaeser and Gottlieb, 2006; Carlino and Saiz, 2008).

To investigate whether the positive or negative properties of cities matter more for household quality of life, scholars have predominantly used two methods: the hedonic pricing approach based on the Rosen-Roback framework and analysis of responses to surveys on subjective well-being. The hedonic pricing approach studies capitalization of local amenities in labor and house markets and infers the values of amenities from geographical variation in wages and house prices. Studies based on surveys infer the contribution of places to well-being from answers to questions about how happy or how satisfied respondents are with their lives or places of residence.

The two methods rely on different assumptions. Whereas the hedonic pricing approach assumes perfect geographical mobility of households, studies using surveys of subjective well-being assume that respondents in different places employ the same response scale, that is, assign the same meaning to each response category.

Given the widespread use of two methods that rest on distinct assumptions, it would be reassuring if the methods lead to the same conclusion. However, we are not aware of any study that has used both methods to examine quality of life in cities and compared the results. This paper aims to go some way towards filling this gap in the literature.

Whereas the fundamental positive and negative attributes of cities are universal as they follow from co-location of a large number of people in a limited geographical area, the relative importance of various attributes varies between cities. Some cities have an abundance of attractive attributes that make them pleasant places to live, whereas negative qualities dominate in other cities, suggesting that each city should be studied separately.

In this paper we will study Oslo, the capital and biggest city of Norway. Drawing on comprehensive register and survey data, we compute and compare estimates of quality of life in Oslo relative to the rest of the country using both the hedonic pricing and subjective well-being methods. Another contribution is that we provide separate estimates for population groups according to their geographical mobility. Since the hedonic pricing method rests on the assumption of perfect mobility, this approach will not necessarily give the correct result for less mobile population layers.

The next section describes and compares the hedonic pricing and subjective well-being methods and motivates our contribution. We then provide background information about Norway and Oslo, and present our datasets and the results. The paper ends with a concluding discussion.

Quality of life in cities

None of the predominant methods for measuring quality of life – hedonic pricing based on the Rosen-Roback model and analysis of subjective well-being - have provided unambiguous conclusions about the relation between quality of life and urban scale.

The basic premise of the Rosen-Roback model (Rosen 1979, Roback 1982) is that firms locate where they obtain the highest profit and households locate to maximize utility, where utility is a function of real wages and local amenities. The (re)location decisions of firms and households affect local wages and prices. In equilibrium, households are indifferent over locations. Places with low endowments of amenities compensate with relatively high real wages, whereas amenable places display relatively low real wages. Thus, the hedonic pricing approach predicts that real wages will be higher (lower) in places that have lower (higher) quality of life. In practice, households are not perfectly mobile, and Bayer et al. (2009) show that the Rosen-Roback model may give inaccurate results in the presence of migration costs.

A large number of studies have used the Rosen-Roback framework to compute estimates of the values of local amenities, such as high-quality schools, safe neighborhoods, attractive climate and clean air (Hoehn et al., 1987; Blomquist et al., 1988; Gyourko and Tracy, 1991; Gabriel and Rosenthal, 2004; Buettner and Ebertz, 2009; Carlsen et al., 2009; Ebertz, 2012; Shapiro, 2012; Albouy et al., 2013; Boualam, 2014; Gibbons et al., 2014; Albouy, 2016;

Garretsen and Marlet, 2017). The literature has not reached an unambiguous conclusion on the urban gradient of quality of life. For instance, Berger et al. (1987) find a negative relation between quality of life and city size in the U.S., whereas Albouy (2012) finds that larger American cities display higher quality of life than smaller cities.

The literature on subjective well-being utilizes survey questions on life satisfaction, happiness and place satisfaction to assess quality of life in different locations (a review is provided by Wang and Wang (2016)). Among the studies that investigate geographical variations in life satisfaction and happiness in industrialized countries, several find lower subjective well-being in cities compared to less populous areas (Berry and Okulicz-Kozaryn, 2011; Sørensen, 2014; Piper, 2015; Lenzi and Perucca, 2016; Requena, 2016; Okulicz-Kozaryn, 2017; Winters and Li, 2017; Okulicz-Kozaryn and Mazelis, 2018). However, there are also studies that find no robust urban-rural differences in subjective well-being (Shucksmith et al., 2009, Easterlin et al., 2011, Glaeser et al 2016).

A voluminous literature studies how satisfied inhabitants are with their residential city/area (Insch and Florek, 2008; 2010). However, few of these studies relate place satisfaction to urban scale. Recently, the European Commission has performed survey investigations of inhabitants in about 80 European cities, where questions about life and place satisfaction are included (European Commission 2013, 2016; Weziak-Bialowolska, 2016; Okulicz-Kozaryn and Valente, 2019). These surveys show a negative relation between population size and satisfaction with life and place, and place and life satisfaction are strongly correlated (Okulicz-Kozaryn and Valente, 2019).

Whereas the hedonic pricing approach requires perfectly mobile households, there is no such requirement for the subjective well-being approach to be valid. Interpersonal subjective rankings are based on the assumption that respondents use the same scale, such that response categories are comparable across individuals. If the mean respondents in different places use (approximately) the same scale, geographical variation in subjective well-being provides information on geographical differences in quality of life. It is not obvious how population mobility correlates with geographical variation in response scale. Hence, whereas the hedonic pricing approach is more appropriate for mobile population groups, one cannot say whether the subjective well-being approach is most appropriate for mobile or for less mobile population groups.

In a series of papers, Ferreira and co-authors discuss and compare hedonic pricing and subjective well-being in evaluating local amenities in Ireland and find that the methods generally arrive at different conclusions (Brereton, Clinch and Ferreira, 2006; Moro et al., 2008; Ferreira and Moro, 2010). However, they do not compare how the methods rank quality of life in cities compared to other places of residence. Neither do they examine how the two methods perform for different population groups.

In this paper, we compare quality of life in the capital of Norway, Oslo, with quality of life in the rest of the country using both the hedonic pricing method and survey data on place satisfaction. We analyze place satisfaction instead of life satisfaction or happiness because we have access to a comprehensive and detailed Norwegian survey of place satisfaction. As the hedonic pricing approach is most appropriate for mobile households, we divide the population into mobility quartiles and compare results from the two methods for each mobility quartile.

The city of Oslo

In this study, the urban-rural dichotomy will be represented by the capital Oslo relative to the rest of the country.[1] Oslo is 2.4 times bigger than the second largest municipality (Statistics Norway, 2019a) and exhibits many of the positive and negative attributes that are standard for large cities. The average income in Oslo is considerably higher than the country average (Statistics Norway, 2019b), but the city has a higher share of households with low income (Normann, 2009) and higher wealth and income inequality (Wessel, 2000; Wiborg, 2017). Among the Norwegian municipalities, Oslo has the second highest population share with higher education, and the highest population share of immigrants (Statistics Norway, 2019c, 2019d).

Oslo typically scores high on rankings of cultural amenities (Kommunal Rapport, 2018). The city boasts the only three-star Michelin restaurant in the country and ranks among Lonely Planet's best places to travel (Lonely planet, 2017). But Oslo is also plagued by congestion; according to the Tomtom traffic index, Oslo has the second largest traffic jam problem among the cities in the Nordic countries and the largest traffic jam problem in Norway (Tomtom, 2018). Of cities in Norway, Oslo has a relatively high level of air pollution (Norwegian Institute of Public Health, 2015). And, compared to other police districts in Norway, Oslo has the highest number of offences per capita (Statistics Norway, 2019e).

The city has seen substantial population increases over the last decades. From 2002 to 2019, the population swelled by 33 per cent from 513 000 to 681 000 (Statistics Norway, 2019a),

[1] This excludes investigation of very disaggregated place attractiveness. Analyses of, for instance, neighborhoods, gentrification and `right to the city' are therefore beyond the scope of this paper.

and in this period, the capital's share of total population increased from 11.3 to 12.8 per cent (Statistics Norway, 2019a). The rise in house prices was even stronger. From 2002 to 2018, per square meter transaction price of villas in the capital leaped by 184 per cent, whereas the consumer price index only increased by 38 per cent (Statistics Norway, 2019f, 2019g).

Data

The analyses in this study employ four datasets with information on relocations, wages, house prices and place satisfaction, respectively. For three of the datasets - on relocation, wages and place satisfaction - the units of observation are individuals, whereas for the dataset on house prices, the units are transactions. The three datasets on individuals are censored at ages 25 and 66. Since the statutory retirement age is 67, few people above 66 are represented in the wage dataset, and many individuals below 25 have not yet completed their education. The relocation, wage and house price datasets are compiled from administrative registers of Statistics Norway, whereas the dataset on place satisfaction is put together from surveys collected by TNS Gallup. Summary statistics are provided in Tables 1 and 2.

The relocation dataset is employed to compute estimates of the propensity to relocate as a function of sociodemographic characteristics. The propensity estimates can be allocated to the individuals in the wage and place satisfaction datasets as the latter datasets comprise the same population groups and include the same sociodemographic characteristics as the relocation dataset. The wage and house price datasets are used to compute wage and house price differentials between Oslo and the rest of the country. More detailed descriptions of the datasets follow.

Relocations

To measure geographical mobility, we use relocations across Statistics Norway's 90 travel-to-work areas, denoted economic regions. These regions have been computed based on information about commuting flows between municipalities. A move between regions usually involves changing both resident community and job.

To characterize the mobility of different sociodemographic groups, we investigate relocations between regions from 2007 to 2012. We have compiled a detailed dataset of the whole population present in Norway both at the beginning of 2007 and the beginning of 2012. About 11 per cent of the population changed regional affiliation in this five-year interval (see column 1 of Table 1). We have also considered the period 2002-2012 in supplemental analysis without change of conclusions. Our investigation of mobility only considers interregional migration; migrants to and from Norway are omitted from the analysis as they are not present at both timestamps. This leaves us with about 2.5 million person observations.

[Table 1 about here]

Column 1 of Table 1 presents the sociodemographic variables used to explain the decision to relocate: 5-year age intervals, male, married, parent (defined as the presence of a child below 18 in the household), immigrant status (foreign born), and tertiary education (defined as at least one year of completed university/college).[2] About fifty per cent are married; approximately 42 per cent have children, while 36 per cent have higher education. Close to 9 per cent of the population are born abroad.

[2] Age and other sociodemographic characteristics are registered in 2012.

Nominal wages

The wage dataset covers the period 2001-2010 and is collected from four registers administered by Statistics Norway: the population, education, tax and employment registers. The population and education registers give information on all sociodemographic variables needed to allocate workers to mobility quartiles. The tax register gives information about annual income from employment, and the employment register provides yearly information about employment contracts, including the number of hours worked per week. We derive a measure of hourly wage from the income and employment contract data.[3] A worker is included in a given year if he/she is between 25 and 66 years old at the beginning of the year, leaving us with an unbalanced panel of yearly data for approximately half a million workers, with a total of about 6 million person-year observations.

The means and standard deviations of key variables can be found in column 2 of Table 1. Comparison with the total population shows that the wage sample has a somewhat larger share that is male and a lower share that is 50 years or older. This is as expected, as the wage dataset is restricted to fulltime workers predominantly in the private sector.

[3] In a given year, employees are included if they have at least one full-time contract, no more than two contracts and work three months or more. We exclude workers in the primary and public sectors, as the wages in these sectors are to a substantial degree determined by national regulations rather than by market forces. We have no information on overtime work. Hourly wages will thus be overestimated for workers with many overtime hours.

House prices

The dataset on house prices originates from Statistics Norway's house transaction register and encompasses all house transactions except those administered by housing cooperatives. We have data for about 427,000 transactions in the period 2005-2010, including rich data on house characteristics: square meters, age of house, house type, type of ownership, number of rooms, house facilities and location. Summary statistics can be found in Table 2 (and Table A.1. provides further details).

[Table 2 about here]

An average dwelling in Norway is about 97 square meters with 3.4 and 2.3 rooms and bedrooms, respectively, and the mean price is just above 2 million kroners (about 225,000 USD). An average unit is close to 41 years of age, an apartment and privately owned. 66 per cent of the units are occupied by their owner(s). Concerning house amenities, about 27 per cent of the units have a balcony or similar facilities, 23 percent have a garage available, and over 16 percent have a fireplace.

Place satisfaction

Our survey dataset is composed of large national postal surveys conducted annually by TNS Gallup during 1994-2000 and again in 2003 and 2005. The questionnaire includes the following question about place satisfaction:

"All things considered, how satisfied or dissatisfied are you with your municipality as a place to live?"

Response alternatives are discrete numbers from 1 to 6, where 6 is `very satisfied' and 1 is `very dissatisfied'.

Each year thirty to forty thousand persons received the survey. About 50% returned the questionnaire, of which 98.2 per cent answered the question about place satisfaction. We pool the surveys, producing altogether 158,230 respondents. The surveys included resident municipality and all sociodemographic variables used in our analysis of relocation: age, gender, marital status, children, education level and immigrant status.[4] We omit 15,440 respondents that did not supply one or more of these variables, as well as 31,523 respondents below 25 or above 66 years of age, leaving 111,267 respondents for the analysis.

Column 3 of Table 1 lists means and standard deviations for place satisfaction and sociodemographic variables. Comparison with the total population in column 1 of the table shows that the survey sample has a somewhat larger share that is married and a lower share of immigrants.

[4] With three exceptions, definitions of sociodemographic variables are identical in the relocation and survey datasets. First, in the survey dataset, marital status does not distinguish between marriage and cohabitation, whereas the relocation dataset, which is based on administrative registers, does not have information about cohabitation. Second, the relocation data define children as 18 years and younger while the survey dataset operates with a threshold of 17 years of age. Third, the relocation dataset defines tertiary education as at least one year of completed college/university, while in the survey dataset, the respondents are asked to state if they have higher education, but the questionnaire does not provide a definition of higher education.

Empirical specifications and results

Relocation propensity

In this section, we examine how the propensity to relocate depends on sociodemographic variables and use the results to allocate the population into mobility quartiles. The following linear probability model is estimated:

$$m_i = Age_i\beta_0 + Age_iMale_i\beta_1 + Age_iMarried_i\beta_2 + Age_iChildren_i\beta_3 + Age_iTertiaryEducation_i\beta_4 + Age_iImmigrant_i\beta_5 + u_i$$

where m_i is an indicator equal to unity if person i changed resident region from 2007 to 2012. Age_i is a vector of 5-year age intervals. The indicator variables - $Male_i$, $Married_i$, $Children_i$, $TertiaryEducation_i$ and $Immigrant_i$ - are interacted with the age vector to allow for age varying effects of demographic variables, and u_i is an error term assumed to have the standard properties.

[Table 3 about here]

It follows from the results presented in Table 3 that the propensity to relocate declines monotonically with age. The interaction between age and being male is mainly positive, suggesting that males have higher relocation probabilities. Married people have lower probability to relocate, except for the youngest age group. Parents are less likely to relocate, but the association becomes weaker with age and turns positive for the oldest age group. Persons with higher education have a higher likelihood of relocation, and the associations between education level and mobility are quite large. Compared to natives, immigrants have in general a higher propensity to change region.

From the results of Table 3, we compute predicted relocation probabilities for each individual based on his/her sociodemographic characteristics. Persons with the highest predicted migration propensity are native-born married females aged 25-29 without children and with tertiary education, of which 44.7 per cent changed region from 2007 to 2012. The lowest migration propensity have native-born married females aged 50-54 with children and without tertiary education. For this group, the relocation probability is only 1.1 per cent.

Based on the predicted propensity to relocate, we allocate the population aged 25-66 in 2012 into quartiles. All persons in the fourth quartile have relocation probabilities above 14.7 per cent, whereas the first quartile encompasses persons with relocation probabilities below 3.4 per cent. The thresholds between the four quartiles are used to allocate individuals in the wage and survey datasets into mobility quartiles.

Hedonic pricing analysis

In this section we use data on wages and house transactions to compute estimates of real wages in Oslo compared to the rest of the country for the four mobility groups.

The Oslo nominal wage premium

Each worker-year observation in the wage dataset is allocated to one of the mobility quartiles dependent on the workers' sociodemographic characteristics of the first year they are observed. The following panel data regression is estimated:

$$ln(HourlyWage)_{it} = \alpha_i + \alpha_t + Oslo_{it}Mobility_j\beta_j + Age_{it}Female_i\beta_F + Age_{it}Male_i\beta_M + \beta_U UpperSecondaryEduc_{it} + \beta_T TertiaryEduc_{it} + \epsilon_{it}$$

where the dependent variable is the natural logarithm of hourly wages for worker *i* in year *t*. α_t is year fixed effects. $Oslo_{it}$ is an indicator of living in Oslo, and $Mobility_j$ is a vector of indicators for belonging to mobility quartile *j*=1,4. β_j is a vector of parameters that gives the nominal wage premium of Oslo for each mobility quartile. We include sex-specific indicators of age and education level indicators as controls as these sociodemographic variables change over time and are associated with labor productivity. The other sociodemographic variables are mainly picked up by the worker fixed effects, α_i. The worker fixed effects will also handle geographical sorting of unobserved worker characteristics like ability (Combes et al., 2008, 2010; Mion and Naticchioni, 2009). ε_{it} is the error term.

[Table 4 about here]

Table 4 presents the estimated Oslo nominal wage premiums for the four mobility quartiles. From column 1, we see that all mobility groups earn more in cities, and the premium is monotonically increasing in mobility. The least mobile population group earns 1.5 percent more in Oslo than in the rest of the country, whereas the corresponding number for the most mobile population group is 4.7. The Wald tests in column 2 confirm that the results for more mobile groups are statistically different from that of the least mobile group. These conclusions do not depend on the controls included in the specification. In columns 3-4, we have included only the Oslo dummy interacted with mobility quartiles and worker fixed effects, and the estimates of the Oslo premium change very little.

The Oslo house price premium

Since all inhabitants in a region face the same house market, the Oslo house price premium does not vary across mobility quartiles. The following regression is fitted to estimate how much house prices in Oslo differ from the rest of the country:

$$
\begin{aligned}
ln(HousePrice)_{im} \\
&= \alpha_m + \beta_S Oslo_i + Size_{im}\beta_{SIZE} + Age_{im}\beta_{AGE} + Type_{im}\beta_{TYPE} + Facilities_{im}\beta_{FAC} \\
&+ \epsilon_{im}
\end{aligned}
$$

where *i* refers to dwelling and *m* refers to the 72 months in our sample period, 2005-2010. The dependent variable is the natural logarithm of transaction price of dwelling *i* in month *m*, α_m are month fixed effects, and $Oslo_i$ is unity if the dwelling is located in the capital. $Size_{im}$ is a vector that includes net and gross size of the unit and these values squared, and indicators for the number of rooms and bedrooms. Age_{im} is a vector of age categories, while $Type_{im}$ is a vector of indicators of type of unit (detached, semi-detached, etc.) and ownership characteristics. $Facilities_{im}$ is a vector of facilities and amenities, such as balcony, boat place, garage, garden and fireplace. ε_{im} is the error term. The full specification can be found in Appendix Table A.1. The Oslo coefficient is displayed in column 5 of Table 4.

The estimated coefficient of Oslo is 0.318 (t-value~118). Hence, the house price level is about 32 per cent higher in Oslo than in the rest of the country.

Real wages and quality of life in Oslo

Local prices are a function of local house prices and local prices of other goods and services. As an approximation, we assume that only house prices vary geographically.[5] The average budget share of housing in Norway during 2001-2009 was approximately 22 per cent (Statistics Norway, 2012). If other prices don't vary nationwide, the price level in Oslo is approximately $32\times0.22\approx7$ per cent higher than in the rest of the country, which is larger than the estimated nominal wage premiums for all mobility quartiles. Hence, based on the hedonic pricing approach, we conclude that Oslo has lower real wages and therefore more valuable household amenities for all mobility quartiles, and the difference between Oslo and the rest of the country is biggest for the least mobile population groups. The conclusion that quality of life is higher in Oslo is not affected by the national tax scheme. Because of progressive income taxation and regional tax exemptions in certain municipalities, the national tax share in Oslo is somewhat higher than in the rest of the country. Tax considerations would therefore make relative real wages in Oslo even lower.[6]

Place satisfaction

The following OLS regression is estimated:[7]

[5] Goods sold close to where they are produced should in principle be cheaper because of transportation costs. The prices of services should reflect local factor prices.

[6] Municipal taxes are irrelevant to our exercise since they are used to pay for public services to the residents of the municipality.

[7] Since answers to survey questions are discrete, the reported regressions were also estimated using ordered probit models, and all conclusions carry over.

$$
\begin{aligned}
PlaceSatisfaction_{it} &= \alpha_t + Mobility_j \beta_j + Oslo_{it} Mobility_j \beta_{Oj} + Age_{it} Female_{it} \beta_F + Age_{it} Male_{it} \beta_S \\
&+ \beta_M Married_{it} + \beta_C Children_{it} + \beta_T TertiaryEducation_{it} + \beta_I Immigrant_{it} \\
&+ \epsilon_{it}
\end{aligned}
$$

where $PlaceSatisfaction_{it}$ is the level of satisfaction reported by respondent *i* in year *t*. α_t are year fixed effects. As for the analysis of nominal wages, $Mobility_j$ is a vector of indicators for belonging to mobility quartile *j*=1,4. $Oslo_{it}$ is unity if the respondent lives in Oslo municipality. β_{Oj}, *j*=1,4, is a vector of parameters that gives place satisfaction in Oslo compared to the rest of the country for each mobility quartile. As controls, we include sex-specific age indicators, $Married_{it}$ (equal to unity if the respondent is married/cohabiting), $Children_{it}$ (a dummy for the presence of children below 17 in the household), $TertiaryEducation_{it}$, (a dummy that is unity if the respondent reported that his/her highest education was college/university), and $Immigrant_{it}$ (a dummy for being foreign born). ε_{it} is the error term. The sociodemographic variables are included as explanatory variables in the regression to control for possible direct effects of these variables on place satisfaction and for effects on the response scale used by respondents.[8]

[Table 5 about here]

Table 5 presents the estimated effect of living in Oslo on place satisfaction for the different mobility quartiles. We see that the coefficient of Oslo increases with mobility (column 1). In the two lowest quartiles, respondents living in Oslo are less satisfied with their resident

[8] Studies have found associations between sociodemographic variables and happiness/life satisfaction (Diener et al., 1999).

municipality than respondents in the rest of the country. In the third quartile there is no significant difference between Oslo and other municipalities, whereas in the highest quartile, place satisfaction is significantly higher in Oslo. For the three highest mobility groups, the estimated effect of living in Oslo is statistically different from that of the least mobile group (column 2).

Our results are hardly affected by inclusion of sociodemographic controls. From column 3, we see that also without sociodemographic control, the least mobile groups are less satisfied with Oslo, and the most mobile group is more satisfied with Oslo.

Concluding discussion

To our knowledge, this is the first paper that uses two distinct methods – hedonic pricing and analysis of surveys on subjective well-being – to measure and compare quality of life in a specific city. Since the hedonic pricing approach assumes that households are perfectly mobile, we have divided the population into mobility quartiles. The two methods arrive at the same conclusion for the most mobile population group: quality of life is higher in Oslo than elsewhere. For the other mobility groups, the methods yield different results: place satisfaction is lower or the same in the capital, whereas the hedonic pricing model suggests that quality of life is higher in Oslo.

Our results suggest that both the subjective well-being approach and the hedonic pricing approach can be used to measure quality of life for the most mobile population segment. For less mobile groups, our results indicate that the hedonic pricing approach is not suitable; the theoretical assumptions of the Rosen-Roback model are violated, and the method gives a different conclusion than the subjective well-being method.

Our interpretation of why low-mobile households report low levels of place satisfaction in Oslo is the following. Although the capital has considerably higher levels of nominal income and education than the rest of the country, Oslo has also higher wealth and income inequality and more poverty. Due to the combined effects of inequality and high housing prices, some segments of the population are not able to find attractive neighborhoods that are affordable. Of these households, the more mobile can relocate outside the capital, whereas the less mobile are forced to remain in less attractive neighborhoods and thus report low place satisfaction. Hence, for these households, low real wages do not reflect high quality of life, as assumed by the Rosen-Roback model, but rather eroding of real wages due to being stuck in a city with soaring prices.

If the hedonic pricing approach gives inaccurate results for less mobile population groups, it would seem natural to recommend that, for these groups, surveys of subjective well-being are used to study geographical variations in quality of life. However, we cannot rule out that our results for low mobility groups are due to weaknesses of the subjective well-being method. For instance, our results can reflect geographical variation in the use of response scale. It is well-known that psychological traits vary geographically (Rentflow et al., 2008), and subjective well-being is correlated with psychological traits (DeNeve and Cooper, 1998; Diener et al., 1999). A potential method to adjust differences in response scale is the use of `vignettes' – hypothetic situations that the respondent is asked to evaluate (King et al., 2004). Unfortunately, the available Norwegian surveys do not include vignettes.

Our paper is related to a literature that discusses and compares hedonic pricing and subjective well-being in evaluating local amenities (Brereton, Clinch and Ferreira, 2006; Moro et al., 2008; Ferreira and Moro, 2010). The authors find that the two methods typically arrive at different conclusions. Our results support the findings of these papers and suggest that different conclusions are due to the less mobile segments of the population for which the assumptions underlying the hedonic pricing approach is not valid.

To our knowledge, this is the first paper to investigate the relation between mobility and quality of life. However, other classifications of the population may also be of interest. Several scholars argue that cities are particularly attractive for young, educated and single people (Costa and Kahn, 2000; Clark et al., 2002; Florida, 2002, 2017; Glaeser et al., 2001; Moos, 2016; Okulicz-Kozaryn and Valente, 2019). A potential extension of our study would be to conduct separate analyses by population characteristics like age, sex, education, health status and family situation.

In our investigation we don’t consider lower geographical units than economic region or municipality. A promising avenue for extending our research is to investigate smaller areas, for instance city districts and neighborhoods. It would also be interesting to study whether our conclusions for place satisfaction carry over to surveys on life satisfaction and happiness.

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Declaration of interest statement

The authors declare that there is no conflict of interest.

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Data availability statement

Register data are available under license from Statistics Norway and the survey data under license from TNS Gallup. Contact the authors for access to Stata codes on model specifications.

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Table 1. Summary statistics. Relocation, survey and wage analyse

	Relocation analysis (1)	Wage analysis (2)	Survey analysis (3)
Male	0.505	0.712	0.486
Married	0.506	0.483	0.764
Children	0.418	0.504	0.420
Tertiary education	0.356	0.282	0.381
Immigrant	0.085	0.052	0.020
Age 25-29	0.105	0.079	0.097
Age 30-34	0.108	0.160	0.139
Age 35-39	0.124	0.182	0.147
Age 40-44	0.137	0.163	0.140
Age 45-49	0.131	0.136	0.131
Age 50-54	0.122	0.112	0.128
Age 55-59	0.117	0.100	0.102
Age 60-66	0.155	0.071	0.117
Change of resident region, 2007-2012	0.108		
	(0.310)		
Hourly wage (NOK)		226.9	
		(107.3)	
Self-reported place satisfaction			4.47
			(1.01)
Years	2012	2001-2010	1994-2000, 2003, 2005
Units	Persons	Person-years	Persons
N	2,530,905	6,088,411	111,267

The table displays means and standard deviations (in parentheses).

Tabel 2. Summary statistics. Analysis of house prices

	Mean	Std.dev.
Size (in square meters)	97.1	54.4
Gross size (in square meters)	129.2	80.6
Number of bedrooms	2.33	1.14
Number of rooms	3.41	1.62
Floor	2.62	1.86
Age of building (in years)	41.0	31.7
Type of property:		
Detached	0.29	0.45
Semi-detached	0.05	0.22
Townhome	0.07	0.26
Apartment	0.58	0.49
Ownership:		
Private property	0.63	0.48
Share	0.35	0.48
Stock	0.02	0.15
Owner-occupied	0.66	0.47
Amenities:		
Renovated	0.06	0.24
Garage	0.23	0.42
Balcony	0.27	0.44
Fireplace	0.16	0.37
Common washroom	0.08	0.28
Garden	0.08	0.28
Elevator	0.08	0.27
House price (NOK)	2,020,473	1,333,129
N	427,184	

Notes: Summary statistics for key variables in housing transaction dataset. Further details on dataset can be found in Table A.1.

Table 3. Explaining relocation between regions. Linear probability analysis

	Coefficients	Standard errors
Age 25-29	0.246***	(0.002)
Age 30-34	0.183***	(0.002)
Age 35-39	0.123***	(0.002)
Age 40-44	0.102***	(0.001)
Age 45-49	0.081***	(0.001)
Age 50-54	0.069***	(0.001)
Age 55-59	0.061***	(0.001)
Age 60-66	0.050***	(0.001)
Male x age 25-29	-0.022***	(0.002)
Male x age 30-34	0.020***	(0.002)
Male x age 35-39	0.024***	(0.001)
Male x age 40-44	0.014***	(0.001)
Male x age 45-49	0.010***	(0.001)
Male x age 50-54	0.006***	(0.001)
Male x age 55-59	0.003***	(0.001)
Male x age 60-66	0.003***	(0.001)
Married x age 25-29	0.034***	(0.003)
Married x age 30-34	-0.013***	(0.002)
Married x age 35-39	-0.026***	(0.001)
Married x age 40-44	-0.030***	(0.001)
Married x age 45-49	-0.034***	(0.001)
Married x age 50-54	-0.042***	(0.001)
Married x age 55-59	-0.040***	(0.001)
Married x age 60-66	-0.030***	(0.001)
Children x age 25-29	-0.075***	(0.002)
Children x age 30-34	-0.047***	(0.002)
Children x age 35-39	-0.033***	(0.002)
Children x age 40-44	-0.042***	(0.001)
Children x age 45-49	-0.030***	(0.001)
Children x age 50-54	-0.016***	(0.001)
Children x age 55-59	-0.005***	(0.001)
Children x age 60-66	0.009***	(0.002)
Tertiary education x age 25-29	0.167***	(0.002)
Tertiary education x age 30-34	0.155***	(0.002)
Tertiary education x age 35-39	0.080***	(0.001)
Tertiary education x age 40-44	0.033***	(0.001)
Tertiary education x age 45-49	0.015***	(0.001)
Tertiary education x age 50-54	0.011***	(0.001)
Tertiary education x age 55-59	0.010***	(0.001)
Tertiary education x age 60-66	0.011***	(0.001)
Immigrant x age 25-29	-0.002	(0.003)
Immigrant x age 30-34	0.005*	(0.003)
Immigrant x age 35-39	0.042***	(0.002)
Immigrant x age 40-44	0.053***	(0.002)
Immigrant x age 45-49	0.046***	(0.002)
Immigrant x age 50-54	0.040***	(0.002)
Immigrant x age 55-59	0.030***	(0.002)

Immigrant x age 60-66	0.023***	(0.002)
N	2,530,905	
Adj. R-squared	0.196	

Dependent variable: dummy variable equal to one if region in 2007 ≠ region in 2012. The specification does not include a constant term. Robust standard errors are in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

Table 4. Estimated wage and house price premiums of Oslo for different mobility groups

	Wage regressions				House price regression
	With sociodem. covariates		Without sociodem. covariates		
	Regression (1)	Wald test (2)	Regression (3)	Wald test (4)	(5)
Oslo × first quartile mobility	0.014**		0.015***		
	(0.006)		(0.006)		
Oslo × second quartile mobility	0.031***	6.42**	0.033***	6.39**	
	(0.004)	(0.011)	(0.004)	(0.012)	
Oslo × third quartile mobility	0.032***	8.36***	0.031***	6.05**	
	(0.003)	(0.004)	(0.003)	(0.014)	
Oslo × fourth quartile mobility	0.047***	33.27***	0.045***	25.79***	
	(0.001)	(0.000)	(0.001)	(0.000)	
Oslo					0.318***
					(0.003)
N	6,088,411		6,088,411		427,184
Adj. R-squared	0.724		0.722		0.306

The dependent variables are the natural log of hourly wage and house price. Fourth quartile is the most mobile group and first quartile the least mobile group. The wage regressions include full set of worker and year fixed effects. The specification in column (1) includes age-by-gender fixed effects and indicators of education level. The Wald tests show if the coefficients are similar to the Oslo coefficient of the first mobility quartile. The full specification of the house price regression is found in Table A1. Robust standard errors and Wald test significance are in parentheses.

*** p<0.01, ** p<0.05, * p<0.1

Table 5. Effect of living in Oslo on reported place satisfaction for different mobility groups. OLS regressions

	With sociodem. covariates		Without sociodem. covariates	
	Regression	Wald test	Regression	Wald test
	(1)	(2)	(3)	(4)
Oslo × first quartile mobility	-0.179***		-0.153***	
	(0.036)		(0.036)	
Oslo × second quartile mobility	-0.084***	3.79*	-0.060*	3.65*
	(0.032)	(0.051)	(0.033)	(0.056)
Oslo × third quartile mobility	0.016	17.93***	0.038	17.08***
	(0.028)	(0.000)	(0.028)	(0.000)
Oslo × fourth quartile mobility	0.083***	37.31***	0.080***	29.56***
	(0.022)	(0.000)	(0.023)	(0.000)
N	111,294		111,294	
Adjusted R-squared	0.020		0.010	

Fourth quartile is the most mobile group and first quartile the least mobile group. All regressions include year and mobility group fixed effects. Regression (1) also includes: sex-specific age indicators, and dummy variables for married, children, tertiary education and immigrant. The Wald tests show if the coefficients are equal to the Oslo coefficient for the first mobility quartile. Robust standard errors and Wald test significance are in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table A1. Estimated house price premium of Oslo. OLS regression

	Coefficients	Standard errors
Oslo	0.318***	(0.003)
Size (in square meters)	0.002***	(0.000)
Size squared	-0.000***	(0.000)
Gross size (in square meters)	0.002***	(0.000)
Gross size squared	-0.000***	(0.000)
Age: 1-5 years	-0.116***	(0.005)
Age: 6-10 years	-0.174***	(0.005)
Age: 11-20 years	-0.269***	(0.005)
Age: 21-30 years	-0.350***	(0.005)
Age: 31-50 years	-0.406***	(0.005)
Age: 51-100	-0.385***	(0.005)
Age: >100 years	-0.294***	(0.006)
House type: detached	0.154***	(0.020)
House type: semi-detached	0.243***	(0.021)
House type: townhome	0.313***	(0.021)
House type: apartment	0.297***	(0.020)
House type: multi-family residential/apartment building	0.273***	(0.043)
House type: farm	0.047*	(0.026)
Ownership: share	-0.206***	(0.002)
Ownership: stock	-0.025***	(0.007)
Ownership: bond	-0.724***	(0.061)
Other type of ownership	-0.165***	(0.038)
2 rooms	0.231***	(0.007)
3 rooms	0.260***	(0.007)
4 rooms	0.298***	(0.007)
5 rooms	0.337***	(0.007)
6 or more rooms	0.392***	(0.008)
1 bedroom	-0.088***	(0.004)
2 bedrooms	0.058***	(0.004)
3 bedrooms	0.142***	(0.004)
4 bedrooms	0.195***	(0.004)
5 bedrooms	0.206***	(0.006)
6 or more bedrooms	0.169***	(0.009)
1st floor	-0.033***	(0.006)
2nd floor	-0.008	(0.006)
3rd floor	0.029***	(0.006)
4th floor	0.033***	(0.006)
5th floor	0.065***	(0.008)
6th floor	0.049***	(0.011)
Higher than 6th floor	-0.014	(0.009)
Renovated	0.073***	(0.005)
Renovated x age	-0.006***	(0.000)
Balcony	-0.009***	(0.003)
Boat place	0.202***	(0.034)

Garage	0.009**	(0.004)
Fireplace	0.110***	(0.004)
Common washroom	-0.077***	(0.005)
Garden	0.074***	(0.004)
Elevator	0.045***	(0.005)
Owner lives in unit	0.107***	(0.002)
Constant	13.652***	(0.031)
Observations	427,184	
Adj. R-squared	0.306	

Dependent variable is log(house price). Month-by-year fixed effects are included in the estimation, as well as indicators of missing information. Robust standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table A2. Explaining relocation between regions, including income-age interactions. Linear probability analysis

	Coefficients	Standard errors
Age 25-29	0.218***	(0.002)
Age 30-34	0.178***	(0.002)
Age 35-39	0.131***	(0.002)
Age 40-44	0.116***	(0.002)
Age 45-49	0.095***	(0.001)
Age 50-54	0.082***	(0.001)
Age 55-59	0.074***	(0.001)
Age 60-66	0.058***	(0.001)
Male x age 25-29	-0.036***	(0.002)
Male x age 30-34	0.013***	(0.002)
Male x age 35-39	0.023***	(0.001)
Male x age 40-44	0.018***	(0.001)
Male x age 45-49	0.013***	(0.001)
Male x age 50-54	0.007***	(0.001)
Male x age 55-59	0.003***	(0.001)
Male x age 60-66	0.004***	(0.001)
Married x age 25-29	0.028***	(0.003)
Married x age 30-34	-0.014***	(0.002)
Married x age 35-39	-0.026***	(0.001)
Married x age 40-44	-0.030***	(0.001)
Married x age 45-49	-0.033***	(0.001)
Married x age 50-54	-0.040***	(0.001)
Married x age 55-59	-0.038***	(0.001)
Married x age 60-66	-0.029***	(0.001)
Children x age 25-29	-0.076***	(0.002)
Children x age 30-34	-0.047***	(0.002)
Children x age 35-39	-0.032***	(0.002)
Children x age 40-44	-0.039***	(0.001)
Children x age 45-49	-0.029***	(0.001)
Children x age 50-54	-0.016***	(0.001)
Children x age 55-59	-0.005***	(0.001)
Children x age 60-66	0.009***	(0.002)
Tertiary education x age 25-29	0.159***	(0.002)
Tertiary education x age 30-34	0.149***	(0.002)
Tertiary education x age 35-39	0.081***	(0.001)
Tertiary education x age 40-44	0.038***	(0.001)
Tertiary education x age 45-49	0.020***	(0.001)
Tertiary education x age 50-54	0.015***	(0.001)
Tertiary education x age 55-59	0.013***	(0.001)
Tertiary education x age 60-66	0.015***	(0.001)
Immigrant x age 25-29	0.006*	(0.003)
Immigrant x age 30-34	0.007***	(0.003)
Immigrant x age 35-39	0.040***	(0.002)
Immigrant x age 40-44	0.048***	(0.002)
Immigrant x age 45-49	0.042***	(0.002)
Immigrant x age 50-54	0.036***	(0.002)

Immigrant x age 55-59	0.027***	(0.002)
Immigrant x age 60-66	0.021***	(0.002)
Low income x age 25-29	0.031***	(0.002)
Low income x age 30-34	0.005**	(0.002)
Low income x age 35-39	-0.009***	(0.002)
Low income x age 40-44	-0.015***	(0.002)
Low income x age 45-49	-0.014***	(0.001)
Low income x age 50-54	-0.015***	(0.001)
Low income x age 55-59	-0.020***	(0.001)
Low income x age 60-66	-0.017***	(0.001)
Medium income x age 25-29	0.056***	(0.002)
Medium income x age 30-34	0.009***	(0.002)
Medium income x age 35-39	-0.019***	(0.002)
Medium income x age 40-44	-0.027***	(0.002)
Medium income x age 45-49	-0.027***	(0.001)
Medium income x age 50-54	-0.022***	(0.001)
Medium income x age 55-59	-0.023***	(0.001)
Medium income x age 60-66	-0.022***	(0.001)
High income x age 25-29	0.096***	(0.003)
High income x age 30-34	0.028***	(0.003)
High income x age 35-39	-0.004**	(0.002)
High income x age 40-44	-0.027***	(0.002)
High income x age 45-49	-0.026***	(0.001)
High income x age 50-54	-0.020***	(0.001)
High income x age 55-59	-0.018***	(0.001)
High income x age 60-66	-0.017***	(0.001)
Observations	2,530,898	
R-squared	0.198	
Adj. R-squared	0.198	

Dependent variable: dummy variable equal to one if region in 2007 ≠ region in 2012. The specification does not include a constant term. The lowest income quartile is used as reference category. Robust standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table A3. Estimated wage and place satisfaction premiums of Oslo for different mobility groups. The mobility groups are constructed on the basis of Table A2

	Hourly wage		Reported place satisfaction	
	Regression	Wald tests	Regression	Wald tests
Oslo × first quartile mobility	0.013***		-0.177***	
	(0.005)		(0.032)	
Oslo × second quartile mobility	0.036***	13.00***	-0.078**	4.79**
	(0.004)	(0.000)	(0.032)	(0.029)
Oslo × third quartile mobility	0.031***	9.97***	0.033	22.40***
	(0.003)	(0.002)	(0.030)	(0.000)
Oslo × fourth quartile mobility	0.047***	44.39***	0.071***	39.89***
	(0.001)	(0.000)	(0.022)	(0.000)
N	6,088,411		111,294	
Adj. R-squared	0.724		0.020	

The dependent variable is the natural log of hourly wage and self-reported place satisfaction. Fourth quartile is the most mobile group and first quartile the least mobile group. The wage regressions include full set of worker and year fixed effects, age-by-gender fixed effects and indicators of education level. The place satisfaction regression includes year and age group by gender fixed effects, and dummy variables for married, children, tertiary education, immigrant, income and mobility group. The Wald tests show if the coefficients are similar to the Oslo coefficient of the first mobility quartile. Robust standard errors and Wald test significance are in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

Table A4. Estimated wage premiums of Oslo for different mobility groups. Removing covariates step-wise

	Wage regressions				
	(1)	(2)	(3)	(4)	Actual moving (5)
Oslo × first quartile mobility	0.014**	0.014**	0.014**	0.015***	0.014**
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
Oslo × second quartile mobility	0.031***[b]	0.031***[b]	0.031***[b]	0.033***[b]	0.029***[b]
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Oslo × third quartile mobility	0.032***[a]	0.032***[a]	0.032***[a]	0.031***[b]	0.029***[b]
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Oslo × fourth quartile mobility	0.047***[a]	0.047***[a]	0.048***[a]	0.045***[a]	0.048***[a]
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Education	Y	N	N	N	Y
Gender x age group fixed effects	Y	Y	N	N	Y
Age group fixed effects	N	N	Y	N	N
N	6,088,411	6,088,411	6,088,411	6,088,411	6,088,411
Adj. R-squared	0.724	0.724	0.724	0.722	0.724

The dependent variable is the natural log of hourly wage. Fourth quartile is the most mobile group and first quartile the least mobile group. In column (5) the mobility quartiles are computed based on raw probabilities (number of moves relative to group size). The wage regressions include full set of worker and year fixed effects. Robust standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1
Significance of Wald test of different effect than for the least mobile group displayed on paratheses, a: p<0.01, b: p<0.05

Table A5. Estimated place satisfaction premiums of Oslo for different mobility groups. Removing covariates step-wise

	Place satisfaction regressions				
	(1)	(2)	(3)	(4)	Actual moving (5)
Oslo × first quartile mobility	-0.179***	-0.177***	-0.165***	-0.153***	-0.174***
	(0.036)	(0.036)	(0.037)	(0.036)	(0.036)
Oslo × second quartile mobility	-0.084***[c]	-0.091***[c]	-0.083**[c]	-0.060*[c]	-0.098***
	(0.032)	(0.032)	(0.032)	(0.033)	(0.032)
Oslo × third quartile mobility	0.016[a]	0.006[a]	0.024[a]	0.038[a]	0.023[a]
	(0.028)	(0.028)	(0.028)	(0.028)	(0.029)
Oslo × fourth quartile mobility	0.083***[a]	0.077***[a]	0.079***[a]	0.080***[a]	0.078***[a]
	(0.022)	(0.023)	(0.023)	(0.023)	(0.022)
Sociodemographics	Y	N	N	N	Y
Gender x age group fixed effects	Y	Y	N	N	Y
Age group fixed effects	N	N	Y	N	N
N	111,294	111,294	111,294	111,294	111,294
Adj. R-squared	0.020	0.019	0.014	0.010	0.020

The dependent variable is self-reported place satisfaction. Fourth quartile is the most mobile group and first quartile the least mobile group. In column (5) the mobility quartiles are computed based on raw probabilities (number of moves relative to group size). The regressions include year and mobility group fixed effects. Robust standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Significance of Wald test of different effect than for the least mobile group displayed with letters, a: p<0.01, c: p<0.1