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# City love and place quality assessment of liveable and loveable neighbourhoods in Rotterdam

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ABSTRACT

After the worldwide interest in global sustainability and climate change challenges, an increasing concern is voiced on local quality of life and neighbourhood liveability. In recent urban studies, human well-being, satisfaction and happiness studies are gaining much popularity in a local context (the 'microcosmic city'). The present study seeks to identify the determinants of the residents' appreciation for their daily environment, called here '*city love*'. The latter concept captures both tangible or material aspects of city life ('*body*') and immaterial and emotional dimensions of local quality of life ('*soul*'). The present paper seeks to develop and test a new quantitative '*city love*' concept, inspired by the *soul* and *body* conceptualisation of urban attractiveness for residents and visitors – based on a novel '*feelgood*' index (FGI) and a '*human habitat*' index (HHI) –, with a view to map out the citizens' contentment or appreciation (called *neighbourhood love index* – NLI) at a district or neighbourhood scale in the city of Rotterdam. Our study utilises data from a quantitative survey among thousands of residents located in 63 neighbourhoods in this city. In addition, the Rotterdam dataset contains not only survey data, but also register data on these neighbourhoods, e.g., real-estate values, crime statistics, and socio-demographics, while geographical information from OpenStreetMap (OSM) is added as a complement. In addition to a multivariate analysis of the rich data set, the paper employs also a quantile regression analysis extended with fixed effects. The results show that the coefficients of the *feelgood index* (FGI) and the *human habitat index* (HHI) decrease slightly as we move up the distribution of the *neighbourhood love index* (NLI). This means that physical and functional aspects of neighbourhoods, e.g., access to such amenities as public transportation, sport facilities, and also streets with diverse attractions or bikeable and walkable road networks, become more important for the lower end of the distribution of the *neighbourhood love index* (NLI). Our neighbourhood-specific analyses show that the Rotterdam districts and neighbourhoods differ substantially in many physical and social-emotional respects, which calls for place-based policies and sub-local well-being initiatives.

## 1. Introduction

In the emerging '*urban century*', the dilemma between large-scale urban agglomerations ('*urban empires*'; see Glaeser et al., 2021) and human-scale urbanity ('*cities4people*'; see Gehl 2013; Kourtit et al., 2020a) has become a pressing scientific and policy issue that calls for original analytical approaches and effective policy responses. In recent years, the digital technology in particular has offered many unforeseen and novel data opportunities for a decentralised citizen-inspired perspective on handling the complexity of urban life. In the '*New Urban World*' (Kourtit, 2020) citizens are not passive actors anymore, but cognitive and active agents whose decisions, priorities and behaviours impact current and future cities. Concern on the daily living environment is a contemporary characteristic of an urbanised world, in which sustainable, resilient and inclusive cities play a dominant role. Quality of life and liveability have assumed a prominent place on the human well-being ladder. Liveable cities are places where people want to be and to live. But where can such places be found? And what

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determines the attractiveness of such cities?

Over the past years, several studies have been undertaken to measure the attractiveness of places, the residents' or visitors' appreciation of the urban climate, the quality of life conditions in the urban environment, the perceived liveability in the city by its residents, and more recently, the neighbourhood satisfaction of citizens or the state of urban happiness (see e.g. Lee et al., 2008; Revi et al., 2014; Almeida et al., 2016; Ballas, 2018; Carlsen and Leknes, 2021; Kourtit et al., 2020b; Youssoufi et al., 2020; Wahlstrom et al., 2020; Kourtit et al., 2020c). All such studies aim to portrait and explain the place (or neighbourhood) quality of cities by means of extensive data either based on a range of statistically measured indicators, collected through surveys or questionnaires, or social media information on perceived place quality.

Meanwhile, in the past decades sustainable development has received intense attention, a collective urban interest that has been accelerated since the introduction and worldwide acceptance of the UN Sustainable Development Goals (SDGs). It is increasingly recognised that cities and urban agglomerations are key players in tackling recent sustainability challenges, as contemporary dense spatial settlement patterns have the potential to create a better place quality and an inclusive and sustainable future for all. Responsive cities and effective local governance are thus instrumental in shaping new opportunities for an improved quality of life at local or regional level all over the globe.

With the world-wide joint acceptance and gradual implementation of the New Urban Agenda, the goal of sustainable urban development is becoming a centre piece of urban planning and policy. Cities – and urban agglomerations – are increasingly seen as the escalators of environmentally-benign and climate-positive development. Meanwhile, it is also broadly recognised that cities are in general heterogeneous spatial units whose districts and neighbourhoods display an enormous diversity in environmental quality conditions, liveability profiles, well-being perceptions and ecological behaviour of citizens. Consequently, we witness in the past years a rising interest in spatially disaggregated approaches regarding '*neighbourhood sustainability*'. An extensive and informed overview of thousands of publications on the concept of neighbourhood sustainability can be found in a recent study by Grazieschi et al. (2020), who performed a text mining analysis of this concept at both geographical and temporal level so as to create distinct clusters of this concept, mapping out different socio-economic, cultural quality-of-life, and climatological features in urban areas in different regions of the world. Clearly, the interest in place quality is on a rising edge.

Place quality refers to the living conditions in city areas or districts that support – or comply with – urban sustainability, as advocated in particular in the New Urban Agenda of United Nations (Quito, Ecuador, October 17–20, 2016). The place quality concept captures a broad collection of (individual and collective) urban well-being indicators, such as environmental quality, transportation access, security and safety, sanitation, affordable housing, green spaces, or cultural amenities (Andrews, 2001; Balsas, 2004; Esmaeilpoorarabi et al., 2019; Stessens et al., 2020; Grimes et al., 2021). Place quality is therefore, a multidimensional umbrella concept which encapsulates the determinants of satisfactory or happy city life. According to an earlier study by Myers (1988), the constituents of urban quality of life refer to the citizens' contentment with neighbourhood environments, access to open space, external health conditions, traffic conditions, job opportunities, quality of housing, or crime rates. Meanwhile, a wealth of literature has emerged on place quality. From the large collection of applied studies on place quality we will present here concisely a few illustrative cases.

In a recent report on the '*State of New Yorkers – A Well-Being Index*' by the Centre for Innovation through Data Intelligence (2019) an extensive study was pursued on the '6 NYC Policy Domains' and related indicators that shape the well-being of New Yorkers. These domains comprised: education, health and well-being, economic security and mobility, housing, personal and community safety, and core infrastructure and services. After an extensive data collection and analysis – by using inter alia multivariate statistical methods – the authors were able to measure and map out the overall well-being in New York at a spatially disaggregated neighbourhood level. The resulting geographical well-being pattern showed a great diversity and socio-economic heterogeneity at the New York neighbourhood level.

In a totally different context, Ghasemi et al. (2018) studied the spatial pattern of liveability in 22 districts of Tehran Metropolis. The authors used a large number of ecological and quality of life indices at a district level in this city. They used a standard deviational ellipse approach, followed by a multicriteria analysis (viz., an additive weighting method) to identify patterns of high and low liveability among the districts in Tehran. Their quantitative case study showed also significant differences in the liveability conditions in the Tehran districts, in particular in regard to environmental services. It seems thus plausible that cities are heterogeneous spatial units that find mainly a coherence in historical, planning and administrative regulatory systems.

A third interesting study on the disaggregate nature of urban well-being can be found in Ala-Mantila et al. (2018), who addressed – both conceptually and empirically – the association between subjective well-being of citizens and a range of geographically relevant factors in their close urban living environment. Using GIS-based neighbourhood data and controlling for objective and subjective spatial characteristics and socio-spatial moderator factors in urban areas in Finland, the authors found that individual well-being is to some extent based on spatial background variables, but that the degree of intensity of this relationship is co-determined by the subjective well-being measure used.

Recent urban research, as exemplified by the above applied studies, shows clearly a rising interest in the sub-local (i.e., district or neighbourhood) level of city life. The need for a meso scale of analysis in urban research was recently advocated by Kourtit and Nijkamp (2018) in their study on the '*microcosmic city*', a concept based on a functional and social decomposition of the urban territory in terms of detailed data on urban quality of life (see also Kourtit, 2021). In the vein of this rapidly increasing interest in measuring spatial quality of life through appropriate metrics (see e.g. Veenhoven, 2000a; Morrison, 2020, 2021; Okulicz-Kozaryn, 2013; Schmidt-Traub, 2018), the present study aims to develop and test a new '*city love*' concept – inspired by the '*soul*' and '*body*' conceptualisation of the city and neighbourhood attractiveness for residents and visitors – which will be called the '*Neighbourhood Love Index*' (NLI) and which will be decomposed into two respective sub-indicators, namely; '*Feelgood Index*' (FGI) and '*Human Habitat Index*' (HHI). This metrics system serves to describe the citizens' contentment or appreciation of city life at a district or neighbourhood scale. Particular attention will be given to the determinants of differences across neighbourhoods in these indices.

The area of the test site is the Rotterdam metropolitan area. Rotterdam is a fascinating city to study from many perspectives. It is the Netherlands' second largest city and it has experienced tremendous changes during the last 50 years. The built environment has gone through an extensive regeneration process and the population has changed through a large migration influx. Today it is a diverse and multi-ethnic metropolitan area that, on average, has rather happy and well-situated citizens. However, there are substantial differences in urban design, livability and wealth across districts in Rotterdam, which makes it specifically interesting to study on a sub-local, neighbourhood level. Several empirical studies have been undertaken to analyse the spatial well-being aspects of the citizens in this dynamic city. An informed overview can be found in a study by Stouten (2010), who examined the evolution of Dutch urban renewal policy and practice from the perspective of Rotterdam as a major dynamic port city. An interesting applied study was published by Ouweneel and Veenhoven (2018) on life-satisfaction of citizens in Rotterdam in the context of their urban environment. Using survey results, the authors investigated happiness feelings in different districts, which showed both significant inter-temporal and spatial variation.

The present paper is organised as follows. Section 2 will be devoted to the conceptualisation and methodological framing of our analysis. Next, Section 3 will describe the database used, while Section 4 will present the (multivariate) statistical results of our application area (Rotterdam), and will provide the econometric estimations on neighbourhood in Rotterdam based on fixed-effects quantile regression models. Finally, we will offer in Section 5 an interpretation of the findings and conclusions.

## 2. Conceptualisation and methodological framing

### 2.1. Urban quality of life

The implementation of the UN SDG policy and of its subsequent New Urban Agenda implies a formidable task for global and urban governance. Citizens are nowadays – in the digital age – increasingly seen as key actors and carriers of urban sustainability initiatives. And therefore, their perception, attitudes and behaviours regarding the local quality of life are critical parameters for successful local SDG policy. Hence, there is a need for *social indicator systems* that mirror the wellbeing of citizens in regard to their living environment. Useful illustrations are found in urban quality of life (QoL), liveability, happiness, appreciation, or city love studies (see e.g. Morrison, 2021), while examples of operational indicator systems are: neighbourhood sustainability indicators, habitability indicators, satisfaction indicators, feelgood indicators etc. (see e.g. Kourtit et al. 2022). The following questions in particular, are emerging from this new trend in citizen-oriented urban planning:

- Does a collection of evidence-based indicators contribute to a better understanding of SDGs?
- Are the sources of such data systems (ranging from official statistics to social media) sufficiently reliable?
- Are such indicator systems fit-for-purpose in regard to urban sustainability goals?
- Are citizens' interests in place quality adequately mirrored in current statistics and databases on cities?
- Do such indicators provide a solid base for local or neighbourhood sustainability or liveability initiatives and governance?
- Are the data needs of SDG policy on cities adequately covered by the current urban well-being databases and studies?

Over the past years, a wide variety of urban metrics has been designed and applied so as to measure urban quality of life, urban happiness, or liveability in cities (see for an overview Kourtit et al., 2020a; b). Specific applications can inter alia be found in: the '*urban hedonometer*' (e.g., Dodds et al., 2011; Mitchell et al., 2013; Youssoufi et al., 2020), the '*habitability index*' (Echave and Rueda, 2008; Vine et al., 2012). the Rochdale '*feelgood index*',[1] and the '*city liveability barometer*' (see also, Southworth, 2003; Carlos Balsas, 2004; Newman, 2006; Raspe et al., 2010; Joanne et al., 2017; Khorrami et al., 2020). Most of these metric systems can be traced back to the '*urban XXQ*' (maximum quality of urban life) concept advocated by Nijkamp (2008) as a signpost for urban liveability policy. We will offer here a very brief overview of recent approaches to measuring urban well-being and liveability.

According to Frey (2018), happiness and well-being refer to subjective life satisfaction which can in principle be measured. But these measurement tools may be different, e.g. based on surveys (see e.g. Veenhoven, 2000b; Kahneman and Krueger, 2006). A major strand of literature seeks to identify the determinants of happiness or well-being, for instance, economic factors or socio-demographic factors. Less attention however, has been paid to space-specific conditions of life satisfaction.

There is nowadays a great diversity of urban well-being or liveability measures, often of a subjective nature (see e.g. Diener and Suh, 1997; Kamp et al., 2003, Ruth and Franklin, 2014; Schwanen and Wang, 2014). A major strand of recent research on subjective well-being measurement can be found in the urban happiness literature. This new domain started from the perspective of international happiness comparisons (see e.g. Blanchflower and Oswald, 2017; Blanchflower 2021), in which in particular the determinants of happiness were identified, such as freedom, health, marital status, income or good governance. This approach has also gradually entered geography and planning, and has induced the '*geography of happiness*' (see for an overview Ballas, 2018). This new research challenge addresses in particular the spatial, social and demographic constituents of city life, including urban districts and neighbourhoods. Studies in this field are both conceptual (see e.g. Smith and Reid, 2017) and applied modelling oriented (see e.g. Kourtit et al., 2020a; 2020b). Recently, with the rise of social media data, various advanced digital analysis tools (e.g., machine learning) based on content analysis, mood analysis or sentiment analysis have come to the fore, so that also text information (e.g. in the form of tweets) can be used as an input for happiness measurement (see e.g. Diener (2000); Kahneman and Krueger (2006); Kesebir and Diener (2009); Blanchflower and Oswald (2011); Judge and Kammeyer-Mueller (2011); Oswald et al. (2015); Frey and Stutzer (2018); Roessler and Gloor (2021).

The empirical literature on subjective well-being can be distinguished into happiness research and quality of life research (see also Ala-Mantila et al., 2018). In our contribution we seek to combine both factors, by comprising under the heading of 'city love' both subjective survey results and measurable liveability factors. In particular, we add specific spatial and urban factors to our statistical and econometric approach, such as: density perception, access to green, spatial inequality, neighbourhood quality, health conditions and social cohesion. Especially in the period of COVID-19 such factors may play a critical role in well-being perceptions of residents.

In is noteworthy that a great number of empirical well-being, happiness, satisfaction, contentment, liveability or quality of life studies has been pursued in the quantitative urban literature, with a particular view of a disaggregate (district or neighbourhood) scale. Examples can be found inter alia in Andrews (2001), Dissart and Duller (2000), Delmelle and Thill (2014), Ellen and O'Regan (2010), Marans and Stimson (2011), Myers (1998), Royuela et al. (2003), and Royuela (2011). There is apparently a burgeoning interest in urban liveability and happiness studies. In the vein of these quality of life studies, we will position the methodological framing of our research for the city of Rotterdam.

In recent years *city love* studies have gained quite some popularity. Interesting examples can be found in Kageyama (2011), Warnick (2016) and Tai and Ang (2017). However, most of these publications are rather anecdotal and not very analytical. There is a clear need for a more solid, quantitative and evidence-based approach, in which key factors for urban love (including happiness, well-being and satisfaction) are traced and identified. This is the first scope of our study. In addition, there is an overwhelming evidence that the feelings of citizens for their place are not uniformly distributed over the urban space. This heterogeneity calls for a sub-city level of analysis, i.e. districts and neighbourhoods. Neighbourhoods often function as 'small villages' and offer more security and home feelings compared to the city as a whole; the 'good neighbourhood' is often an antidote against 'city evils'. Fortunately, many cities collect data at a neighbourhood level, such as neighbourhood cohesion, environmental quality, safety and health care. In the present study we will apply and test the 'city love' concept to an evidence-based analysis of citizens' wellbeing and human habitat index system as the framing conditions.

[1] https://www.theguardian.com/business/2018/may/27/the-rochdale-feel-good-index-can-you-judge-townwellbeing-from-tweets.

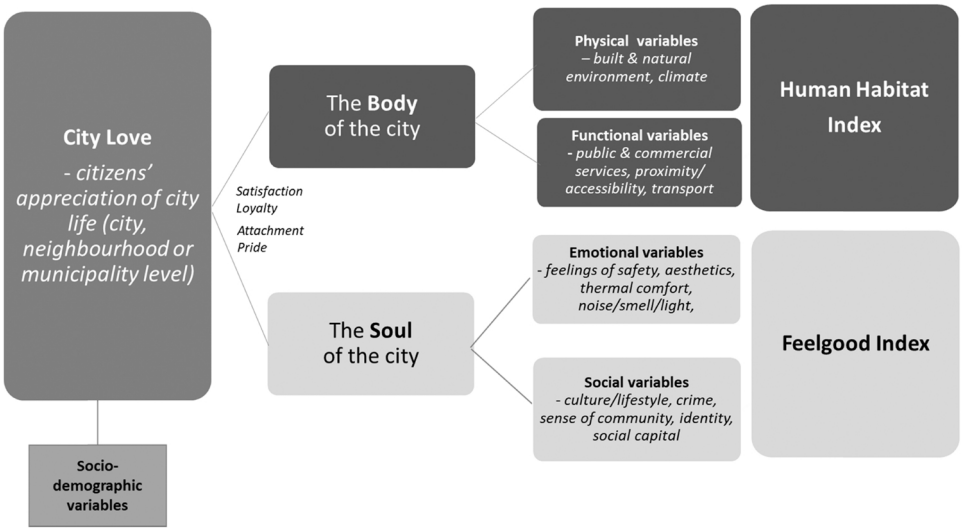


**Fig. 1.** Conceptual model: Assessment of perceived city love – as a function of the city body and soul – through Human Habitat and Feelgood Index.

### 2.2. Conceptual model and operationalisation

The appreciation residents feel for their neighbourhood can, in line with Wahlstrom et al. (2020) and Kourtit et al. (2020a), be studied through the *city love* concept, where the city is decomposed into features relating to its 'body' and 'soul'.

Our conceptual model is illustrated in Fig. 1. The *body* of the city is conceived of as the visible and tangible part of human settlement, in particular, houses, offices, industrial buildings, monuments, green areas, waters, infrastructure, ports, sports and entertainment places, public manifestations, and so forth. To this category of concrete features of a city, one might also add tangible offerings and services provided in the city as well as the physical conditions of the place (e.g. climate, topography, morphology etc.). These components of the city are shaped or adjusted over time by human decisions so as to make the city structure more fit to contemporaneous challenges and purposes. They could for analytical purposes be subdivided into two categories: physical and functional features.

In Fig. 1, the *soul* of the city represents the invisible '*suprastructure*' of a human settlement, in terms of products of the human spirit (Kourtit et al., 2020a), such as residents' feelings of safety, aesthetic perceptions, experience of comfort, sense of belonging and inclusion, perceptions of local lifestyle and culture, crime experiences, social capital (or adversely, social conflict), local democracy, ethnic tension or segregation, sense of community, shared feelings of history or identity etc. Such, less tangible, features could be divided into emotional and social variables. Even though they are less tangible, they can be empirically investigated, certainly in the digital technology age (see e.g. Nguyen et al., 2017; Gloor et al., 2018). Finally, we note that the residents' opinions and attitudes are influenced by their current living situation and socio-demographic status.

Based on this conceptualization we introduce in our study two separate characteristics indices of place quality at district or neighbourhood level, – the *Human Habitat Index*, aiming to quantitatively assess the city body, and the *Feelgood Index* aiming to assess the city soul.

The Human Habitat Index is based on the assessment of physical and functional variables such as transportation, public space, building age and attractiveness, walkability, bikeability, and street attractiveness, while the Feelgood Index captures the assessment of emotional and relational variables such as lifestyle, sense of community, tolerance, feelings of belonging, safety, etc. The stepwise research approach of this study is described in the Appendix. The methodology adopted is systematic and also suitable for urban applications elsewhere.

## 3. Databases

### 3.1. Rotterdam data

In the Atlas for Municipalities in the Netherlands, composed by Marlet and van Woerkens (2017), the largest 50 Dutch municipalities are compared on 50 items. It is noteworthy that Rotterdam scores the lowest on both the municipal happy index and the poverty index. Apparently, the second but largest city in the Netherlands has serious weaknesses in its socio-economic structure, despite the fact that Rotterdam's narrative is dominated by its strong international hub and trade function in relation with its position as the biggest port in Europe. There is undoubtedly a clear need for a solid investigation into the feelings of contentment of the Rotterdam population. Quantitative explanatory research at city and district/neighbourhood level is however, largely absent. A notable exception is an earlier study by Putri (2015), who has made an attempt to gauge happiness and satisfaction levels of citizens based on urban amenities in Rotterdam.

The Rotterdam Neighbourhood data system is very rich – containing both residents' survey and statistical register data from 2014, 2016, 2018 and 2020 about the quality of living and place-related experiences/perceptions of people in 14 city district and over 60 neighbourhoods in Rotterdam. Thus, the database contains both detailed statistical data on many place-based quality-of-life indicators and extensive survey data on the feelings and perceptions of the Rotterdam citizens. The data from Rotterdam are statistically categorized into three major classes: The Safety, Social and Physical Index. These three categories contain each group of themes; each Index contains 5–6 themes (see Table 1). Within these themes a distinction is made between an objective and a subjective score. The objective variables are typically register data or stated facts from the survey, while the subjective variables comprise surveyed preferences, attitudes, or individual valuations of citizens. The scores on the themes are then displayed as an index score, where the average score of Rotterdam has been set at 100 as the baseline measurement (2014). The scores of the 60 neighbourhoods are calculated in relation to this city average.

**Table 1**
Neighbourhood profiles in Rotterdam.

| *Index* | *Safety* | *Social* | *Physical* |
|---|---|---|---|
| *Theme* | *Theft* | *Capacities/skills* | *Real estate* |
| | *Violence* | *Participation* | *Public space* |
| | *Burglary* | *Living environment Bonding* | *Service (provisions)* |
| | *Vandalism* | *Quality of Life exp.* | *Environment* |
| | *Nuisance* | | *Living experiences* |
| | *Safety experience* | | |

### 3.2. OpenStreetMap data

Data on amenities in Rotterdam are also drawn from OpenStreetMap (OSM). As a peer production model, OSM provides user-generated street maps, which are free to use and editable. Using QGIS, we map several amenities available in the Rotterdam area. Fig. 2 illustrates walkable routes, bicycle routes, public transportation stops, and nature. Walkable routes do not require special equipment (special shoes etc.) and are not subject to limitations regarding fitness or weather conditions. Bicycle routes include road sections, trails and dedicated cycle paths. Public transportation stops cover bus stations, tram station and railway stations. Nature describes a variety of landcover features, including trees, grassland, and water.[2]

We can construct street attractiveness variables from OSM to depict and examine the body function of the NLI (see Vine et al., 2012: habitability index for a similar approach). In the present study, the variables are defined over artificially defined points along with the road network of Rotterdam. Points have 50 m distance among them, the points that are directly adjacent to an intersection or roundabout are removed to avoid misleading inferences (Echave and Rueda, 2008; Vine et al., 2012).

The index of walkability, the availability of bicycle networks, natural amenities and diversity of activities available within a 500-metre radius around the street network and historical amenities are considered as relevant parameters for the 'body' definition of the NLI. The walkability is measured by the floating catchment method and a point density tool, which computes the polylines from the road network of Rotterdam that fall within a 500-radius in the raster layer. Then the computed densities are spatially joined with the points. The road network information is retrieved from the OSM, and the roads exclusively devoted to motorised transportation are excluded from the network. The same method is used to compute the availability of bicycle networks and for access to natural amenities. The degree of diversity in the activities along the OSM network uses the same method. The activities are defined with the following attraction weights:

| | |
|---|---|
| Service: | School, preschool, hospital, health center. Attractiveness points: 1 |
| Culture: | Cultural buildings such as e.g. museum, concert hall, gallery, cinema, theater. Attractiveness points: 4 |
| Play and sports: | Sports facilities (municipal and private), playgrounds, ball fields. Attractiveness points: 2 |
| Trade: | All types of trade. Attractiveness points: 2 |
| Restaurant and café: | All types of restaurants and cafes. Attractiveness points: 3 |
| Market trading: | All types of market trade. Attractiveness points: 4 |

Fig. 2 illustrates the concentration of natural amenities, walkable areas (first row), historical surroundings and service diversity (second row), and the age of buildings and bicycle networks (third row) as density measures at points 50 m apart along the road network of Rotterdam. These parameters are then aggregated to the neighbourhood scale. Next, we will pursue a more thorough statistical analysis on the Rotterdam data (Section 4).

[2] See wiki.openstreetmap.org/ for full description.

## 4. Multivariate statistical and econometric analysis

### 4.1. Neighbourhood Love Index (NLI)

The next step in our analysis is the calculation of the Neighbourhood Love Index (NLI), this is calculated as the arithmetic mean of four variables in the Rotterdam data: % **Proud** of neighbourhood, % **Connected** to neighbourhood, % **Satisfied** with neighbourhood, and (100-) % **Relocation (moving) tendency** from neighbourhood. Table 1 reports descriptive statistics for the Neighbourhood Love Index (NLI), the variables building up the index and some other, rather similar, variables. According to Table 1, approximately 2/3 of the 2020 respondents seems to 'love' their neighbourhood (all data – all of Rotterdam). Table 2.

According to Table 3, there are substantial differences between the different districts of the city: The best performing areas are Hillegersberg-Schiebroek and Hoek van Holland, and the worst performing parts are Charlois and Delfshaven. The difference between the highest and the lowest NLI is over 20 points in 2020.

Table 3 shows that NLI for Rotterdam as a whole has, after increasing each year between 2014 and 2018, decreased in 2020. However, the 2020 score is still slightly better than it was in 2014 (67.4 compared to 67). Actually, according to Table 3, almost all city districts experienced a NLI drop between 2018 and 2020, which could be a consequence of the pandemic situation. The only exception is Charlois, where the NLI increased the last two years. Studying the development between 2014 and 2020 we see that NLI has increased in a majority of the districts. However, Charlois, Hoek van Holland, Hoogvliet, Pernis, and Prins Alexander have all experienced a NLI decline during these six years.

### 4.2. Neighbourhood profiles

The Rotterdam data is provided both as individual variables and as indices: the Safety, Social and Physical Index. In Fig. 3 the scores on each index are reported for the 15 city districts of Rotterdam. It can be noted that the most and second most 'loved' neighbourhoods - Hillegersberg-Schiebroek and Hoek van Holland - score relatively high on all three indices. Pernis is another neighbourhood with a high NLI, which scores high on the Safety and Social Indices, but not as high on the Physical Index. Rozenburg scores relatively high on Safety, but not as high on the other two indices–but still this neighbourhood reached a high score on NLI.

According to Fig. 4, the Neighbourhood Love Index in a specific city district seems to be related to its share of residents that are satisfied with their current living situation and their quality of life. Furthermore, the highest performing city district (Hillegersberg-Schiebroek), in terms of NLI, also has the lowest share of low-income residents, while the lowest performing city part (Charlois) has the highest share of low-income residents.

### 4.3. Modelling strategy

In this section, we present our two-step modelling strategy. In the first step, we use factor analysis to construct human habitat and feelgood indices based on the detailed Rotterdam neighbourhood survey and also the data extracted from OSM. Then we use a fixed-effects model to examine the relationship between the NLI and human habitat and feelgood indices.

Factor analysis is a statistical tool that estimates any unobserved structure or pattern underlying a collected data (Kim and Muller, 1978). Operationally, a set of observable variables are reduced to fewer latent variables that are interrelated and share a common variance. The technique allows us to test whether the variables from the dataset lead to composite indicators that are in line with our theoretical model. We first normalise the variables and in order to ensure the least correlation

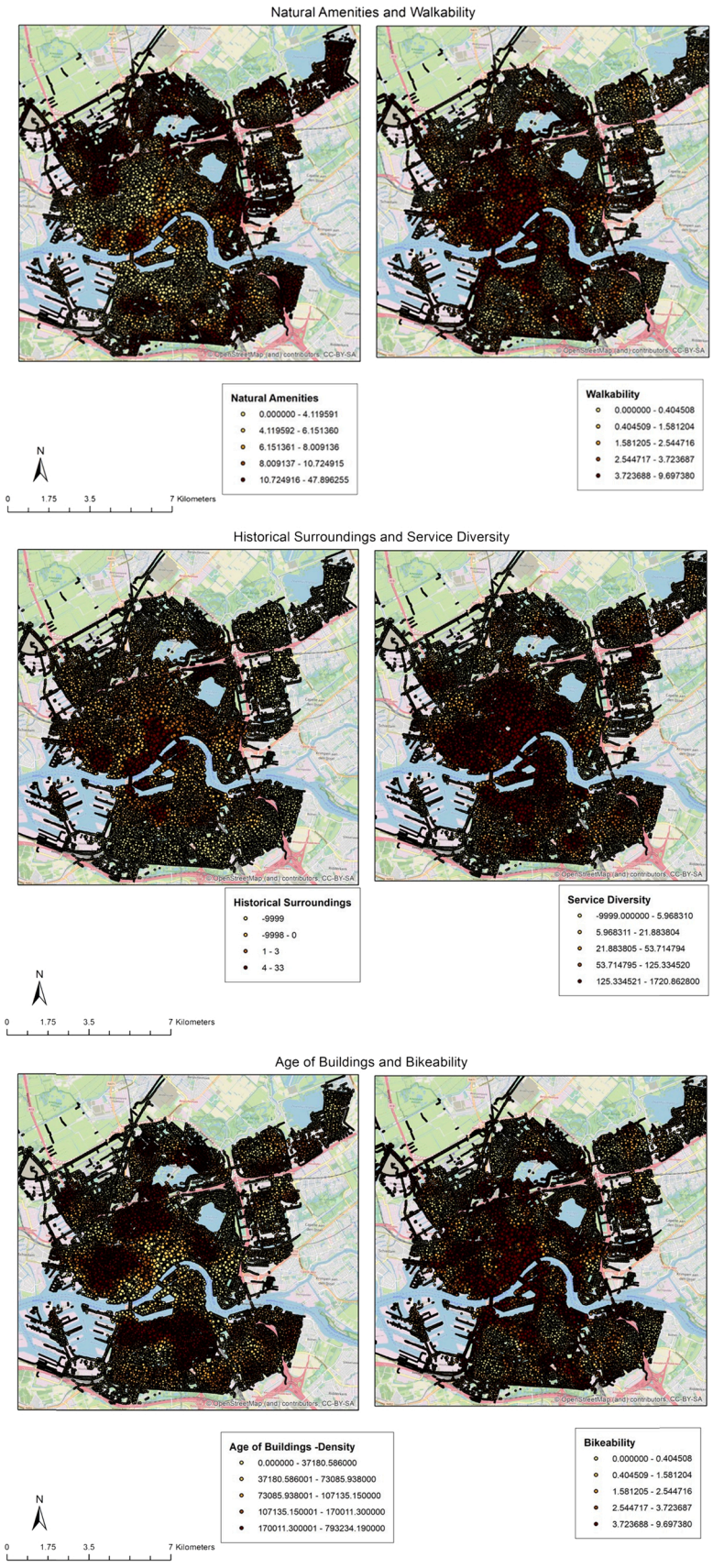


**Fig. 2.** Street attractiveness measures in the Rotterdam area.

**Table 2**
Descriptive statistics for Neighbourhood Love Index (NLI) and its underlying variables. Rotterdam total 2020.

| Descriptive Statistics | N | Minimum | Maximum | Mean | Std. Deviation |
|---|---|---|---|---|---|
| **NLI:** Mean of % Proud, % Connected, % Satisfied, and % Loyal (100-% relocation tendency) | 86 | 40,3 | 87,9 | 67,4 | 10,2 |
| L_Bs_TrotsOpBuurt_p - % residents say they are **proud** of the neighbourhood | 86 | 26% | 81% | 55% | 0,13 |
| L_Bs_VerbondenheidBuurt_p - % residents say they feel **connected** to the neighbourhood | 86 | 34% | 77% | 54% | 0,10 |
| L_Vis6_tevreden - % (very) **satisfied** with the neighbourhood | 86 | 46% | 99% | 78% | 0,12 |
| L_Fis_ALG_Verhuisgeneigdheid_p - % **relocation tendency** from neighbourhood | 86 | 1% | 44% | 18% | 0,09 |

**Table 3**
Neighbourhood Love Index, development 2014 – 2020, scores for each city district and for Rotterdam total.

| Neighbourhood Love Index | 2014 | 2016 | 2018 | 2020 |
|---|---|---|---|---|
| Rotterdam total | 67,0 | 68,1 | 69,3 | 67,4 |
| Charlois | 58,7 | 59,3 | 56,1 | 57,1 |
| Delfshaven | 58,7 | 59,6 | 61,6 | 59,8 |
| Feijenoord | 62,4 | 65,4 | 64,9 | 63,5 |
| Hillegersberg-Schiebroek | 80,6 | 82,2 | 82,5 | 82,0 |
| Hoek van Holland | 80,9 | 82,5 | 78,5 | 77,0 |
| Hoogvliet | 68,6 | 68,3 | 69,6 | 65,7 |
| IJsselmonde | 60,2 | 61,8 | 64,6 | 62,0 |
| Kralingen-Crooswijk | 67,0 | 66,2 | 71,0 | 68,9 |
| Noord | 68,2 | 67,7 | 71,1 | 69,8 |
| Overschie | 73,8 | 76,0 | 75,3 | 73,9 |
| Pernis | 78,9 | 77,0 | 78,5 | 73,5 |
| Prins Alexander | 72,7 | 73,9 | 75,7 | 71,6 |
| Rotterdam | 65,4 | 66,5 | 67,8 | 65,6 |
| Rotterdam Centrum | 67,6 | 69,1 | 73,4 | 71,3 |
| Rozenburg | 68,9 | 75,3 | 76,5 | 70,2 |

among the factors, a rotation procedure is applied. Finally, factors are extracted based on the percentage of variance explained and used as independent variables in the fixed-effects model and quantile regression models with fixed effects.

A fixed effects model[3] for the neighbourhood love function can be defined as follows:

$$y_{it} = \alpha_i + X_{it}\beta + u_{it} \text{for} t = 2014, \quad 2016, \quad 2018 \quad and \quad 2020 \tag{1}$$

where $y_{it}$ is neighbourhood love index computed for neighbourhood $i$, $\alpha_{i!}$ is time-invariant unobserved effects, $X_{it}$ are time-variant effects including feelgood and human habitat indices and $u_{i!''}$ is the error term. In (1) we also control for the share of low-income population in each neighbourhood.

In addition to the fixed effects model, we also estimate quantile regressions with fixed effects to examine whether feelgood and human habitat indices demonstrate varying effects across the distribution of the NLI. Quantile Regression (QR) models are commonly used in various disciplines, especially, when the distributional aspects of the dependent variable are of interest. In the conditional model, regression coefficients are estimated for each conditional quantile of the dependent variable (Koenker and Bassett, 1978). Recent developments allow estimating the quantile regressions with fixed effects for panel data (see Machado and Silva, 2019 for details). QR models allow investigating the relationship between dependent and independent variables outside of the mean values. The method is preferred because it does not assume a parametric distribution and is able to reveal nonlinear relationships. In our case, the QR framework is used to study any heterogeneous relationship between NLI and feelgood and human habitat indices across the distribution of the NLI.

[3] Hausman test statistics pointed out fixed effects model as the efficient alternative over random effects model.

## 5. Fixed effects and quantile regression with fixed effects model results

In this section, we present the results of our two-step regression framework. We start by conducting a factor extraction. The eigenvalue cut-off is determined based on the total variance explained by the extracted factors and by the Kaiser (1960) criteria, i.e. all factors that are above the eigenvalue of 1 are retained. Out of the 19 variables, two factors are extracted, which explain 81% of the total variance in 2020. We note here that factor extractions and factor structures are almost identical over the study years concerned. The rotated factor structure is presented in Table 4 for the year 2020. The items from factor loadings suggest that the variables regarding emotional and social dimensions are better accounted in Factor 1, and physical and functional variables are catered in Factor 2.

The two factors from the analysis are next used as proxies for the *feelgood* and *human habitat* indices in the fixed effects model, while the outputs are presented in Table 5. The same model specification is run by a quantile regression for all deciles; the results are shown in Fig. 5. Table 5 and Fig. 5 illustrate very similar trends, while the feelgood and human habitat indices show a statistically significant and positive association with the NLI. Similar to previous findings (see Wahlström et al., 2020a), emotional and social characteristics are more strongly related to the neighbourhood love than physical and functional amenities for all quantiles. Meanwhile, as shown in Fig. 5, the variables feelgood and human habitat index show a declining trend across the quantiles. Indeed, the coefficients of feelgood and human habitat indies have maximum values at lower quantiles and decrease slightly as we move up along the distribution of the NLI. This means that both emotional and social variables and physical and functional aspects of neighbourhoods become more determinantal toward the lower end of the distribution of NLI. That suggests that improvements in feelgood and human habitat indices will have a higher effect, especially when NLI records lower values.

Finally, adding the share of low-income population as a covariate improves the model fit (see Table 5, column 2) and the results indicate a substantial decrease in the NLI as a response to 1% increase in the share of low-income population. As illustrated by Fig. 5, the concentration of low-income population has a greater negative association with the NLI at higher quantiles, which is the opposite to what is observed for the feelgood and human habitat indices.

However, after controlling for the socioeconomic structure of cities, our results suggest that feelgood and human habitat indices still show positive and significant effects on neighbourhood love. Furthermore, the household income composition of neighbourhoods does not have significant effects at the lower tail of the NLI distribution, where feelgood and human habitat indices have the strongest effect.

## 6. Conclusion and prospect

### 6.1. Retrospect and summary

The overall aim of this paper was to develop and test a new 'city love' concept built on a 'human habitat index' that captures physical and functional amenities in the city, and a 'feelgood index' that assesses

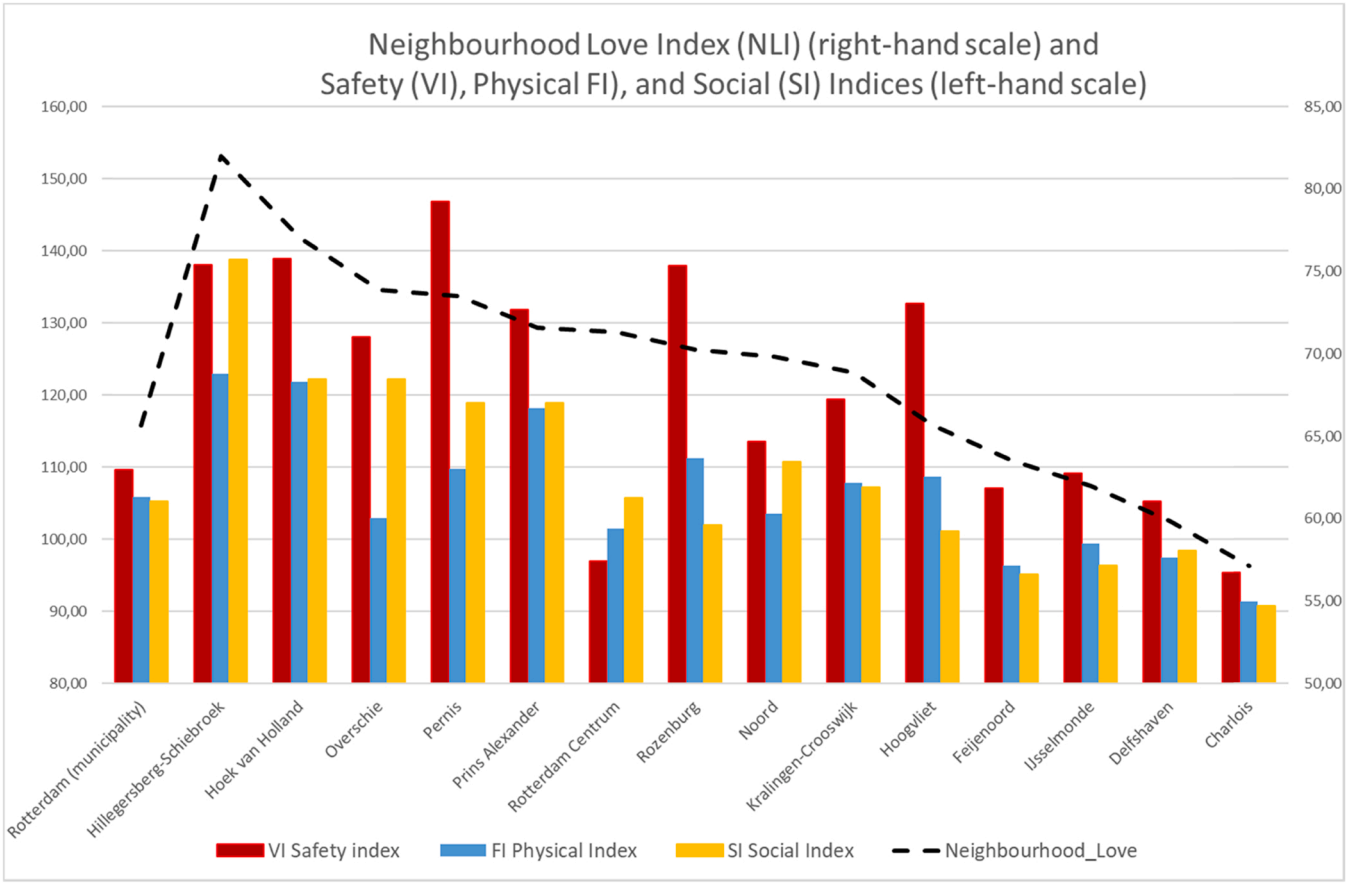


**Fig. 3.** Neighbourhood Love Index (NLI), Safety Index (VI), Physical Index (FI), and Social Index (SI) for all of Rotterdam (municipality) and its 14 city districts, 2020.

emotional and social aspects of the residents' appreciation for their city. Our conceptual model is operationalized using a combination of register and survey data, as well as geographical information from OpenStreetMap (OSM) for the city of Rotterdam. This new model for city love is first tested at the neighbourhood level, i.e. for 14 city districts in Rotterdam. 'City love' is assessed for each district in terms of a neighbourhood love index (NLI), which is a combination of the residents feeling satisfied, attached, loyal to and being proud of their neighbourhood.

The NLI appears to show significant differences between the city districts of Rotterdam, and so does the NLI development over the time period studied (2014–2020). This, as such, supports the need for local and place-based neighbourhood policies and strategies expressed in previous research.

Our multivariate statistical analysis is based on a factor analysis that resulted in a feelgood index and a human habitat index. The feelgood index is built on variables relating to social capital, perceived safety, feelings of inclusion, as well as living in a 'nice' neighbourhood with expensive housing and a few so-called vulnerable multi-family dwellings. The human habitat index is based on variables relating to physical attributes such as street attractiveness, natural surroundings, historical surroundings, and access to sports fields, as well as to functional attributes such as public transportation, and bike-/walkability.

Next, the feelgood index and human habitat index were included in a fixed-effects econometric model, for which also a quantile regression was performed. This fixed-effects model showed that both the human habitat and the feelgood indices are significantly related to the neighbourhood love index (NLI), and that the feelgood index has the strongest quantitative effect on NLI. When controlling for the local socioeconomic structure in terms of 'share of low income' in each neighbourhood, the effects on NLI of both the human habitat and feelgood index remain significant, although their quantitative effect decreases somewhat.

It is worth noting that the findings regarding low-income concentration in specific neighbourhoods are in line with recent literature that explores the inverse relationship between poverty (or risk of poverty) and happiness (S.A. Caria and Falco, 2018; Piff and Moskowitz, 2018). Additionally, as mentioned above, Rotterdam has the lowest position in happiness rankings in the Netherlands (Marlet and van Woerkens, 2017), which is argued to relate to the heterogeneous socioeconomic and demographic structure of the city. Next to this, the present study also shows that there is a considerable within-city variation in neighbourhood love based on income profiles.

The quantile regression results also show that the effects from both the feelgood index and the human habitat index decrease for higher quantiles of the NLI scale. This may imply that strategies and policies targeting urban amenities, have probably more impact in neighbourhoods with a low neighbourhood love index. Furthermore, household income does not have significant effects at the lower tail of the NLI distribution where feelgood and human habitat indices have the strongest effect. From a policy perspective, this means that characteristic indices of place quality captured in our study are potential instruments to improve neighbourhood attachment, also in locations with high socioeconomic heterogeneity.

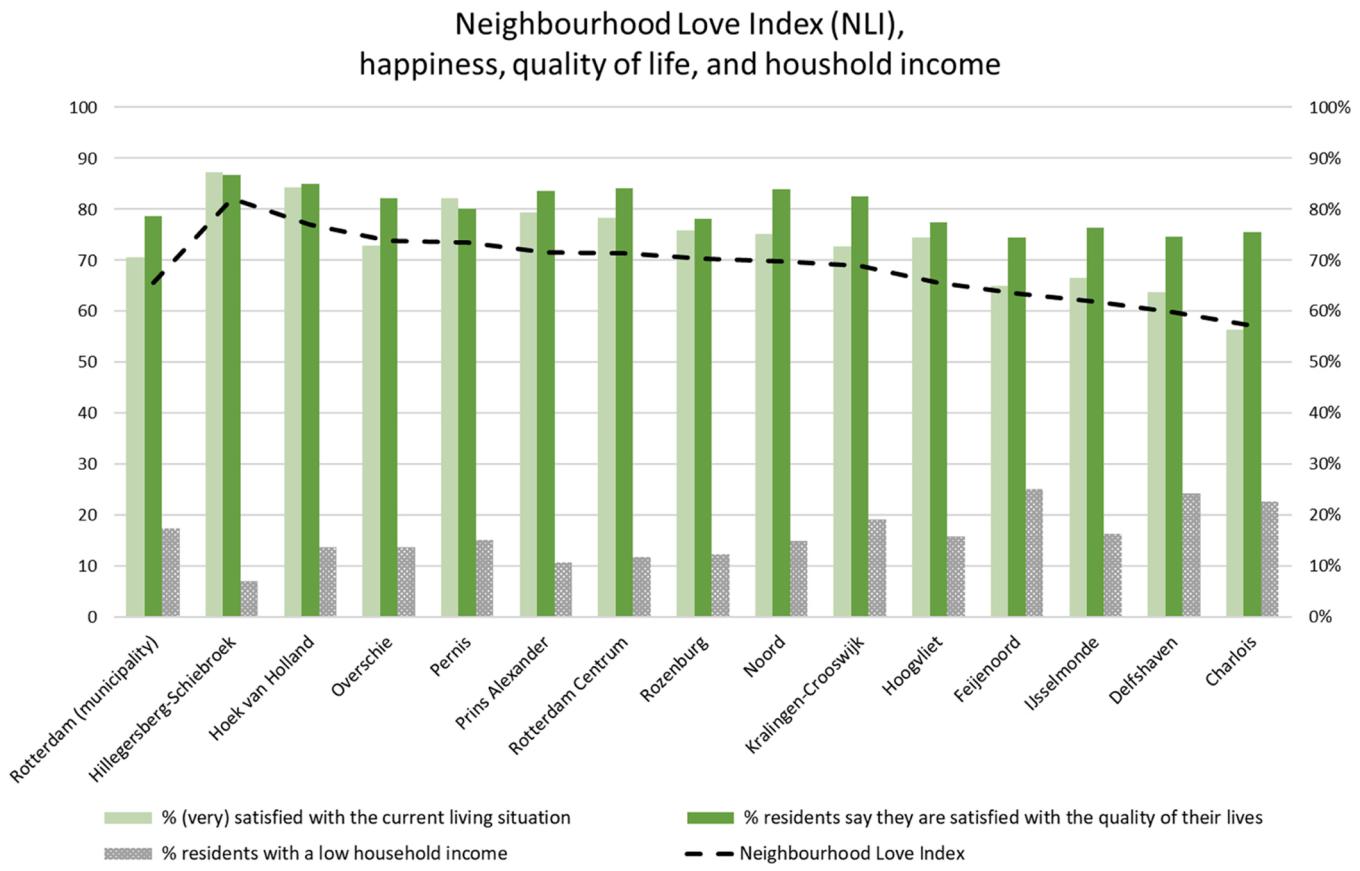


**Fig. 4.** Neighbourhood love index (NLI), satisfaction with current living situation, satisfaction with quality of life, and share of low income houses in the Rotterdam municipality and its 14 city districts.

**Table 4**
Factor Matrix for the year 2020.

| Variable | Factor1 | Factor2 | Uniqueness |
|---|---|---|---|
| Residents help each other | | 0.64 | 0.3774 |
| Residents feel at home with neighbours | 0.7652 | | 0.2465 |
| Residents do not experience discrimination | 0.8001 | | 0.3038 |
| Residents have enough interest for each other | 0.8833 | | 0.2152 |
| Residents have enough help from their families | 0.8774 | | 0.224 |
| Resident do not feel abandoned | 0.9078 | | 0.1758 |
| Women and mean experience harassment least to worse | 0.5972 | | 0.3408 |
| Perceived risk of being a victim least to worse | 0.8931 | | 0.2012 |
| Average score of avoidance least to worse | 0.7367 | | 0.397 |
| Valuation of buildings in the neighbourhood | 0.8191 | | 0.2927 |
| Vulnerable multi families least to worse | 0.7281 | | 0.4604 |
| Sufficient sport fields | | 0.7219 | 0.4765 |
| Street attractiveness | | 0.8249 | 0.3179 |
| Public Transport | | 0.7404 | 0.4341 |
| Historic surroundings | | 0.6068 | 0.3454 |
| Age of buildings | 0.4891 | | 0.7159 |
| Bikeability | | 0.8044 | 0.3194 |
| Natural surroundings | | 0.4947 | 0.6887 |
| Walkability | | 0.3131 | 0.8095 |

Notes: (values represent highest abs(loadings))

### 6.2. *Positioning of the research and future prospect*

The approach adopted in the present study belongs to the broader domain of spatial happiness and well-being research, which ranges from the World Happiness Report (see Helliwell et al., 2017) to regional and urban happiness studies (see Florida et al., 2013). Meanwhile, Marlet and van Woerkens (2017) created even a happiness atlas for municipalities. The happiness and well-being domain is also related to macro approaches as shown in the Human Development Index (HDI) and the Happy Planet Index (HPI). All such studies have clearly shown that happiness is not so much a matter of wealth, but of friendship, health, social capital and a nice environment (Kenzer, 2000; Kahneman and Krueger, 2006; Roessler and Gloor, 2021; Vaillant 2012).

The results presented in this paper contribute to the wealth of literature on urban well-being, geographical happiness, and social sustainability by developing a new combined concept – 'city love' – built on residents' perceptions, register data and geographical information. Clearly, we underscore the need for new and improved metric systems for local urban planning strategies and policy making. This paper has pinpointed the connection between social capital and urban attractiveness, a novel study area which deserves to be further explored. Further research is also needed when it comes to understanding the driving forces explaining why some neighbourhoods experience a continued positive development, while others seems to be stuck in a downward spiral of unemployment, crime, and property degeneration. Our case study on Rotterdam has brought to light interesting findings which need

**Table 5**
Fixed effects model. Model (2) includes the share of low-income population as control.

| | (1) | (2) |
|---|---|---|
| VARIABLES | Fixed Effects | Fixed Effects |
| Feel Good | 5.013 * ** | 4.717 * ** |
| | (0.702) | (0.774) |
| Human Habitat | 1.944 * ** | 1.872 * ** |
| | (0.377) | (0.401) |
| Share of Low Income | | -42.32 * ** |
| | | (10.88) |
| Constant | 67.25 * ** | 89.17 * ** |
| | (0.00707) | (5.634) |
| Observations | 252 | 252 |
| R-squared | 0.82 | 0.83 |
| Number of id | 63 | 63 |
| Neighbourhood FE | YES | YES |

Standard errors in parentheses
* ** $p < 0.01$, * * $p < 0.05$, * $p < 0.1$

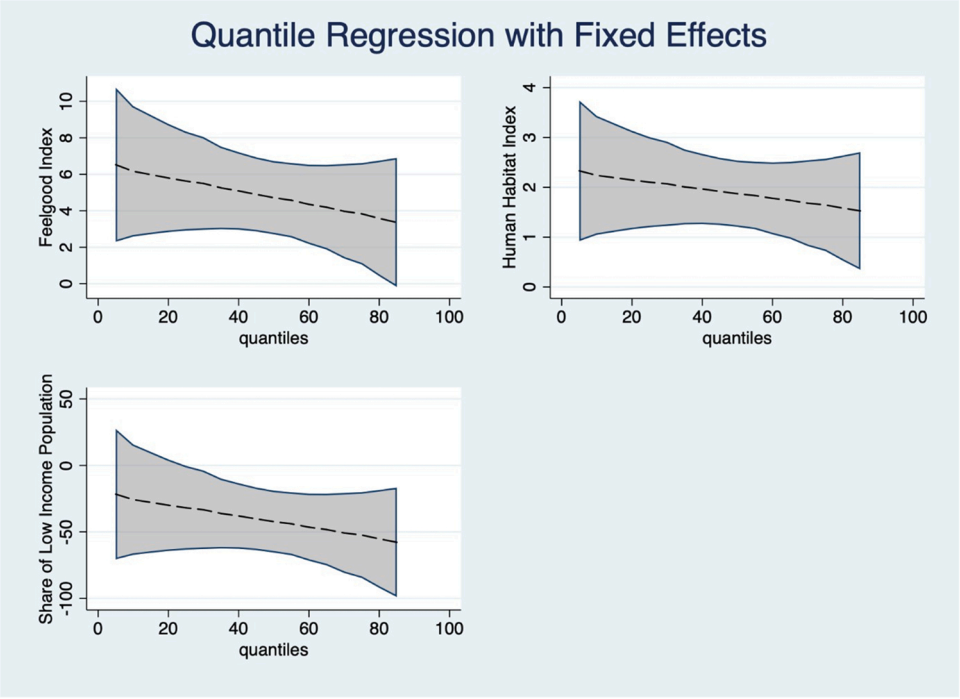


**Fig. 5.** Regression coefficients from quantile regressions with fixed effects. Confidence intervals are shown by the colour grey.

to be empirically examined on their generality by similar studies in other city contexts.

The focus in well-being and happiness research on cities and districts/neighbourhoods, as advocated in the present study, has brought to light a range of critical factors that shape city love. Clearly, people make the city; their feelings of attachment to their neighbourhood (both physically and socially) are essential ingredients of residence-oriented urban planning, a perspective that originates in particular from citizen science. The citizens' love for their local neighbourhood emphasises the policy urgency of people-oriented place-based urban planning from the perspective of sustainability, welfare and inclusiveness. The methodology proposed in the present study opens many avenues for generalisation and testing of city love concepts in other places.

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## Appendix. . Stepwise Research Approach

In this Appendix we present the methods used in our study in the order followed by the paper.

1. The first step is the calculation of the Neighbourhood Love Index (NLI), The NLI is calculated as the arithmetic mean of four variables: the share of residents who say they are: **Proud** of neighbourhood, **Connected** to their neighbourhood, **Satisfied** with the neighbourhood, and who do not have **Relocation (or moving) tendency** from their neighbourhood.
2. In the second step, the indices of walkability, bikeability, natural amenities and diversity of activities are constructed by a floating catchment method (with a 500 m radius) and point density. In the

implementation, measurement points are created along the street network with 50 m distance between them in the GIS environment. Access to attractions and amenities (walkable streets, bicycle networks etc.) is calculated for each point along the street network and aggregated to a neighbourhood scale.

3. In the third step, a factor analysis is conducted to construct human habitat and feelgood indices based on the detailed Rotterdam neighbourhood survey, while also the indices constructed in the second step are included.
4. Finally, a quantile regression framework with fixed effects is employed to examine the relationship between the NLI and human habitat and feelgood indices.

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