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Equity in the City:

On Measuring Urban (Ine)Quality of Life*

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Abstract

We merge contributions from the New Urban Economics and inequality measurement to assess quality of life (QOL) in a given city. We take the point of view of a city planner in favor of an even accessibility to amenities within the city. Instead of the average value of amenities computed in the Roback (1982) QOL index, our index captures the value of its multidimensional "certainty equivalent". We apply this methodology to derive a QOL index for the city of Milan.

Key Words: Urban quality of life, amenities, hedonic prices, inequality index, just city.

JEL Codes: D63, H4; R1; R2.

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1 Introduction

The economic approach to measure urban QOL is based on the work of Rosen (1979) and Roback (1982), who, rather than assessing overall well-being or happiness of households, measure QOL indirectly, in terms of the monetary value of the amenities within the city [1]. Under the assumption that well-being increasing amenities contribute to rise housing prices and to reduce wages, the implicit prices of the amenities are obtained through hedonic regressions on housing and labor markets across cities.

This paper focuses on a single city and extends the previous methodology on urban QOL measurement by introducing the normative judgement of a city planner who is in favor of an equitable urban development, with regard to infrastructures, services and social integration. Albeit the idea of "just city" is embedded both in the planning and economic literature, this paper - to our best knowledge - is the first attempt to introduce the concept of equity in QOL measurement. In the planning literature, the equity-based approach to a just city requires that urban amenities and public services are available in a way such that "everyone receives the same public benefit, regardless of socioeconomic status, willingness or ability to pay, or other criteria; residents receive either equal input or equal benefit" (Talen 1998, p. 24).[2] In the urban economics literature, Berliant et al. (2006) characterize the optimal number and location of public facilities in order to get an "equal treatment and identical provision" across households. They also argue that this objective is in line with several US laws. The priority for equity of the city planner can be also motivated by efficiency purposes: Benabou (1993) shows how stratification can create ghettos, and even bring about a complete collapse of the city's productive capacity. The relevance of local facilities to mitigate well-being inequality has been recently analyzed by Aaberge et al. (2010). Finally, since the quality of city's amenities may represent a circumstance outside the responsibility of inhabitants but able to affect their outcomes, a policy levelling the playing field within the city also promotes equality of opportunities in the sense of Roemer (1998) and Van de Gaer (1993).

[1] Blomquist 2006, p. 484.

[2] An alternative approach (needs-based) follows a "compensatory" criterion that subordinates the distribution of facilities and services to the different needs of the population within the city, in favor of those individuals considered as being in the worst-off conditions. A third approach assumes that the provision of services should be sized according to their demand. Finally, a fourth one is based on market criteria, where the cost of production is the underlying variable. See Lucy (1981) for an exhaustive taxonomy of equity criteria in urban planning.

Our analysis is innovative in two respects: 1) Rather than the actual levels of amenities - defined in most of the past literature[3] as location specific characteristics with positive or negative effects on household's utility -, we take account of their availability. 2) We translate the objectives of the city planner into mathematical properties of an explicit evaluation function. We assume the preference for equity as the social objective: an unequal availability of the amenities within the city has a negative impact on the evaluation function, in the same way as income inequality generates a loss in social welfare according to the Atkinson (1970), Kolm (1969), Sen (1973) approach to inequality measurement (AKS).

Under these assumptions, we are able to derive a new QOL index that can be directly interpreted in terms of the evaluation function. It corresponds to the monetary value of the vector of Equally Distributed Equivalent Amenities (EDEA) available to households. The EDEA is inspired by the certainty equivalent in risk analysis (Pratt 1964) and the equally distributed equivalent income in inequality measurement and their multidimensional extensions (Tsui 1995, Weymark 2006). It is obtained by discounting the vector of the average levels of amenities through a multiplicative correction term belonging to the interval $[0, 1]$. The latter is lower when the distribution of the amenities becomes more unbalanced within the city. The scalar discount factor proves to admit a decomposition in terms of a sum of unidimensional AKS indices, one for each amenity, plus a residual term summarizing the eventual correlation among the amenities' distributions.

One point requires additional comments. Our analysis rests on two different components: the Roback (1982) spatial model and the normative evaluation of the city planner. In the former, the representative agent looks for the most convenient location given the distribution of amenities across districts. The different amenities available at the equilibrium are capitalized into housing prices and the representative citizen's utility is equalized within the city. This outcome is logically independent from the fact that the city planner could reallocate some amenities within the city, affecting in this way the well being of the representative citizen. We reconcile both points of view computing a Roback QOL index based on citizens' evaluation of the availability of the amenities, adjusted by a correction term derived from the evaluation function of the city planner.

A further innovation of our approach is that the weight of each amenity in the planner evaluation function is endogenously determined and not exogenously fixed, often in a discretionary way, as in many social choice exercises.

[3] See Bartik and Smith (1987).

We illustrate our methodology using data for the city of Milan over the period 2004-2008. We consider the availability of education, green areas, recreational activities, commercial facilities and public transportation, and some socio demographic characteristics. We find that taking into account the uneven availability of amenities within the city the Roback index is reduced by 28%.

We proceed as follows: Section 2 develops the theoretical model. In Section 3 we present the empirical application to Milan, discussing data and variables and carrying out a descriptive analysis of the city's neighborhoods. We also discuss the econometric specification of the hedonic function and illustrate the results in terms of amenity prices and the QOL index. Section 4 illustrates the interest of our approach and paves the way for future research.

2 The model

In this section we first illustrate the QOL index developed by Rosen (1979) and Roback (1982). Then we show how to measure the opportunities of households living in different districts in terms of availability of the public goods. Finally, we show how to get the new QOL index accounting for inequality of opportunities at urban level.

2.1 The Roback (1982) quality of life index

Let $\mathbf{a} = (a_1, ..., a_k)$ be the vector of the average quantities of k amenities in a given city. The index developed by Rosen (1979) and Roback (1982) consists of the weighted sum of the values of the k amenities of the city, where the weights are the implicit prices associated to the amenities:

$$QOL = \sum_{j=1}^{k} p_j \cdot a_j. \tag{1}$$

The implicit price p_j, for $j = 1, .., k$ is estimated through housing and wage hedonic regressions. It is the sum of the housing price differential and the negative of the wage differential. In other words, the economic value of a local amenity is determined by the housing price households are willing to pay and the wage they are willing to accept to locate in some city. The idea underlying this approach is that people will accept lower wages and/or greater housing prices in an area with desiderable amenities, but require greater wages and/or lower housing prices in an area with less attractive amenities.[4]

[4] See Blomquist (2006), where all steps to measure QOL between cities are listed, from the collection of data to the validation of results.

As we said in the Introduction, in what follows we will focus on a single city,[5] computing the levels of QOL for each district and an index for the whole city that account for inequality of QOL across districts. This implies three main consequences. First, amenity implicit prices in (1) arise only from the hedonic housing price equation. Wages are neglected since we suppose that they are determined for the city's labor market as a whole without variation within the city. Actually, several studies carried out on American cities show that wages vary also within the city even if the variation is quite modest. According to Bartik and Eberts (2006), for example, wages of identical workers decline about 1% for each additional mile the job is located from the Central Business District (CBD). Even if we would suppose that wages can vary within the city, it was not easy to measure this phenomenon. Indeed we should know where the households go to work, since the neighborhood where individuals live is not necessarily identical to where they work. On top of that, the lack of data on occupation precludes us from admitting within-city wage variation. Secondly, only the prices of amenities that vary within the city can be identified. We then neglect several variables usually considered in between cities analysis (as, for example, weather, altitude etc.) A third potential problem with intra-city analysis is related to spatial sorting on unobservables. The best quality housing units may be located in the best city neighborhoods (Gyourko et al. 1999). We will come back to this point in Section 4.

We now extend the traditional approach to include the city planner's objective of promoting equity.

2.2 From amenities to opportunities

Consider a city exogenously partitioned in n zones. Each zone i is described by a vector $\mathbf{a}_i$ containing the values of the k amenities. The element $a_{ij} \in [0, \hat{a}_j]$ indicates the level of the amenity j in the neighborhood i. Let $\mathbb{D} = \prod_{j=1}^{k} [0, \hat{a}_j]$ represent the domain of the vectors of the amenities. The information on the distribution of amenities in the city is then summarized by a positive matrix $\mathbf{A}$ with dimensions $n \times k$.

[5] A large number of previous studies use data for a single city focusing in particular on environmental issues (air or water pollution, proximity to noxious sites, etc). See, for example, Kohlhase (1991), and Michaels and Smith (1990).

$$\mathbf{A} = \begin{bmatrix} a_{11} & ... & ... & a_{1k} \\ ... & a_{ij} & ... & ... \\ ... & ... & & ... \\ a_{n1} & ... & ... & a_{nk} \end{bmatrix} \tag{2}$$

Suppose that an individual lives in an areal unit with few amenities or none at all. He could anyway benefit from the amenities located in the surrounding areal units. Therefore, the overall quantity of the amenities potentially enjoyed is the sum of the amenities where the individual dwells, plus a term indicating the availability of amenities in the neighborhood, which is a function of the distance among each pair of areal units (see Figure 1).

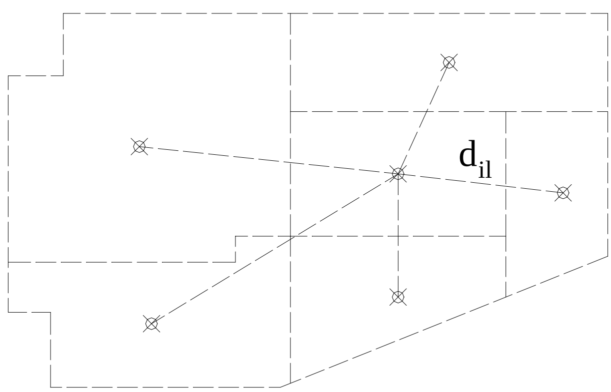

Figure 1: Distance among district centroids.

We consider $\mathbf{A}$ to generate the $n \times k$ matrix $\mathbf{Z}$ whose generic term z_{ij} indicates the overall availability of amenity j for households of neighborhood i. The element z_{ij} is obtained by adding to a_{ij} the availability of the amenity j in the neighborhoods bordering i. In formal terms, defining $S(i)$ the set of neighborhoods adjacent to i (with $i \in S(i)$), we get:

$$z_{ij} = \sum_{l \in S(i)} a_{lj} \cdot f\left(d_{il}\right) \;\; \forall \; j = 1, ..., k \tag{3}$$

where:

- a_{lj} is the value of amenity j in the areal units l bordering i;
- $f\left(d_{il}\right)$ is the value of a continuous and non increasing function $f : \mathbb{R}_+ \rightarrow \mathbb{R}_+$ defined on

the distance d_{il} between the centroids of the areal unit i and those belonging to $S(i)$.[6] We assume $f(d_{il}) = 1$ if $d_{il} \in [0,1]$. This means that households living in a given neighborhood consider amenities of surrounding neighborhoods located within a fixed distance (e.g., a mile) as well accessible as those of their neighborhood. When the distance exceeds this threshold, they account for the lower availability of amenities located in surrounding neighborhoods through an increasing discount factor specified by f.

2.3 The equity-adjusted QOL index

Let us now turn to the model. For any matrix $\mathbf{Z}$, let $W(\mathbf{Z})$ be the city planner's evaluation of a distribution $\mathbf{Z}$ of the k amenities between the n city zones. We assume an additive form of the function W :

$$W(\mathbf{Z}) = \frac{1}{n}\sum_{i=1}^{n} w(\mathbf{z}_i)$$

where $w(\mathbf{z}_i)$ is the value taken by the increasing and concave function w used by the city planner to summarize her assessment about the QOL in the neighborhood i with a vector of amenities $\mathbf{z}_i$.

It is well known (see Weymark 2006) that, under inequality aversion, the value $W(\mathbf{Z})$ will be less than or equal to that guaranteed by an even availability of amenities across neighborhoods. Let $\bar{z}_j$ denote the average level of amenity j in the city and $\overline{\mathbf{z}} = [\bar{z}_1, ...\bar{z}_k]$ the k- dimensional vector containing the means of the k amenities in the city. If $\overline{W} = W(\mathbf{Z})$ is the city planner's evaluation of the actual distribution, by continuity it is possible to define a scalar $\vartheta(\mathbf{Z})$, $\vartheta \in [0,1]$, such that:

$$\overline{W} = W(\mathbf{Z}) = \frac{1}{n}\sum_{i=1}^{n} w(\mathbf{z}_i) = W(\vartheta \cdot \overline{\mathbf{z}}). \quad (4)$$

In the same spirit as Atkinson (1970), we call the elements of the vector $\vartheta \cdot \overline{\mathbf{z}}$ "equally-distributed equivalent amenities", (EDEA) where $\vartheta \leq 1$ expresses the availability of the city planner to sacrifice the share ϑ of the total amount of the amenities against their even distribution within the city. As a result, the Roback index (1) is modified as follows:

Definition 1 *For any* $\mathbf{Z}$*, we define the modified urban quality of life index* QOL_{ϑ} *as:*

$$QOL_{\vartheta} = \sum_{j=1}^{k} p_j \cdot \vartheta \bar{z}_j \quad (5)$$

[6] For a matter of simplicity, we refer to the centroid of the areal unit, namely the geometric center of the plane figure.

where p_{z_j} is the implicit price of the $j-th$ attribute and the "equally-distributed equivalent amenities" $\vartheta\overline{z}_j$, for $j=1,..,k$ are implicitly defined by (4).

Abul Naga and Geoffard (2006) introduced a Cobb-Douglas specification for w:

$$w(\mathbf{z}_i) = \prod_{j=1}^{k} z_{ij}^{\sigma_j} \tag{6}$$

to derive a nice decomposition of ϑ in terms of k unidimensional indices of the Atkinson type computed for each dimension and a residual term accounting for the correlation among the k amenities. Given the unidimensional Atkinson inequality index

$$\gamma_j = \frac{1}{\overline{z}_j} \cdot \left[\frac{1}{n}\sum_{i=1}^{n} z_{ij}^{\sigma_j}\right]^{\frac{1}{\sigma_j}} \tag{7}$$

where $\sigma_j \in [1; -\infty)$, we get the following

Proposition 2 *(Abul Naga and Geoffard, 2006) If $w(\mathbf{z}_i) = \prod_{j=1}^{k} z_{ij}^{\sigma_j}$, with $\sigma_j > 0\ \forall j$, the equivalent share ϑ can be decomposed as follows:*

$$\left(\sum_{j=1}^{k}\sigma_j\right)\ln\vartheta = \sum_{j=1}^{k}\sigma_j \ln\gamma_j + \ln\kappa \tag{8}$$

where $\gamma_1,..,\gamma_k$ are Atkinson univariate indices and $\kappa \geq 1$ is an interaction term equal to:[7]

$$\kappa = \frac{n^{k-1}\cdot \sum_{i=1}^{n}\left(\prod_{j=1}^{k} z_{ij}^{\sigma_j}\right)}{\prod_{j=1}^{k}\cdot \sum_{i=1}^{n} z_{ij}^{\sigma_j}}. \tag{9}$$

Since equations (8) and (9) depend on the vector of parameters $\boldsymbol{\sigma} = [\sigma_1, ..., \sigma_k]$, to implement an empirical analysis it is required to assign a weight to each amenity. This issue is usually solved in multidimensional inequality literature by resorting to sensitivity analysis to show the robustness of the results after reasonable changes in the list of weights. In the QOL setup we may elude this arbitrary choice of the hierarchy among amenities by inferring weights from hedonic regressions. According to Rosen-Roback's location model, implicit prices truly capture the assessment of each amenity by the city's representative citizen. We assume that the higher is the contribute of an amenity in determining the QOL index value, the more intense is the city planner's preference for its even distribution within the city. We fix these concepts in the following assumptions:

[7] The correct formulation of κ is due to Brambilla and Peluso (2010).

i) The weight σ_j associated to each amenity j into the evaluation function (6) is:

$$\sigma_j = \frac{1 - \varepsilon_j}{k - 1} \tag{10}$$

where ε_j is the Pratt (1964) coefficient of relative risk (inequality) aversion over the dimension j.

ii) The Pratt coefficient ε_j is set to be equal to the ratio between the evaluation of the average quantity of the amenity j and the overall assessment of the K amenities within the city. Formally:

$$\varepsilon_j = \frac{p_j \cdot \overline{z}_j}{\sum_{j=1}^{k} p_{z_j} \cdot \overline{z}_j}. \tag{11}$$

Notice that the Pratt coefficient of relative risk aversion ε_j must be interpreted here as the degree of relative inequality aversion of the city planner over the availability of each amenity j. The higher is ε_j, the higher is the loss in the planner evaluation function due to the unequal distribution of the amenity j.

Our methodology can be summarized in the following steps:

- First, we estimate implicit prices of amenities through hedonic regressions.
- Second, we compute ε_j, with $j = 1, ..., K$ from equation (11) and fill up the vectors $\boldsymbol{\sigma} = \begin{bmatrix} \sigma_1, & ..., \sigma_k \end{bmatrix}$ and $\boldsymbol{\gamma} = \begin{bmatrix} \gamma_1, & ..., \gamma_k \end{bmatrix}$ using expressions (10) and (7), respectively.
- Third, we assess the value of ϑ from equation (8) and finally compute the QOL_ϑ index of equation (5).

3 Empirical Application

In this section we employ the previous model to assess urban QOL in Milan, the second largest city in Italy after Rome.[8] Milan is considered one of the richest city of the country and even of the western Europe.[9] Besides being the biggest *Italian* industrial city, it is a historical city which offers

[8] The most recent data issued by the statistics department of the municipality reports in 2008 a total population of $1,295,339$ inhabitants, within an area of about 183 km^2.

[9] In a report published by Barclays Private Clients in May 2002, Milan is considered the third wealthiest city in Europe after London and Paris with a GDP of $ 110.5 billion. Furthermore, according to Milan's provincial government, the province contributes 10 percent of the national GDP and is home to over 45 percent of businesses in the Lombard region and more than 8 percent of all businesses in Italy.

a particular assortment of churches, buildings and monuments mainly gathered inside the *Mura Spagnole*, the circuit of city walls that bound the ancient city center. Despite all these positive aspects, there are other factors that do not positively affect the quality of life. Some neighborhoods have experienced a progressive process of urban decay with increasing poverty, crime problems including drug houses, burglary and prostitution. More and more Italian residents have abandoned these neighborhoods, housing prices have decreased and such neighborhoods often have become the main destination for newcomers in Milan. The next section describes the information used to assess the quality of life in neighborhoods within Milan.

3.1 Data and variables

As we have shown introducing the QOL index *à la* Roback in (1), the overall QOL measure depends on the set of amenities considered implementing the analysis. For the purpose of this study, several data sources are combined into a single data set that contains detailed information on housing and city characteristics. Data on residential housing transactions come from the "Osservatorio del Mercato Immobiliare" (OMI) managed by a public agency ("Agenzia del Territorio"). Transactions are collected at the level of 55 neighborhoods identified by the OMI for a period of 5 years, from January 2004 to December 2008.[10]

A special feature of the OMI data set is that for each observation one of three different types of price is reported in relation to the availability of data: the actual selling price, the offer price (that is the price at which the owner would sell the house) or the estimated price (defined as the likely amount at which a sale would be concluded according to the evaluation of the OMI officers). As regards to the characteristics that define housing units, we consider structural attributes, such as total floor area, age of the building where the housing unit is located at the year of sale, number of bathrooms, whether the housing unit needs to be renovated, whether the housing unit has an independent independent heating system, floor level, presence of a lift or a garage, qualitiy of building.

The neighborhood-level data on amenities and socioeconomic conditions come from the relevant public authorities. They contain information on six important aspects of quality of life: environmental characteristics, public transportation, education, commercial facilities, recreational

[10] See Table A1 and Figure A1 in the Appendix for the list and the map of districts, respectively, with their population size.

activities, and socioeconomic characteristics. Table A2 in the Appendix contains the full list of variables used in our analysis with their sources. We are well aware that while all those variables may contribute to the concept of quality of life we are addressing, they are just an approximation of the set of amenities we would like to have. This paper aims at showing the potentialities of the methodology we employ by using the available information, aiming at conducting an empirical analysis as rigorous as possible. Moreover, city's QOL depends on the revealed preferences of the residents over a set of characteristics, on which it might exist a broad interest. In such a way, residents could be classified in groups, each one of them bearer of specific interests. Married couples should be mainly concerned with the education opportunities for their children and crime rates nearby, or elderly people would have more feeling for facilities such as public transport and health care services provision and finally young-single individuals might seek for local entertainment, recreational places and playgrounds. This means that a QOL index, which excludes some of these variables could not properly represent the interests and the preferences of some groups of residents.[11]

The environmental dimension is proxied by the green areas relative to the area of the neighborhood (*Green*); public transportation is represented by the number of metro stations (*Transport*); commercial facilities (*Commercial facilities*) are proxied by the number of supermarkets, discount stores and malls per $10,000$ inhabitants; recreational dimension (*Cultural*) is proxied by the number of cinemas, theaters, museums, art galleries, academies of music, libraries per $10,000$ inhabitants.

The socioeconomic dimension (*Ethnic*) is based on the ratio of Italian/foreign residents. More precisely, the variable Ethnic for the neighborhood i is constructed as $\frac{It_i}{\sum_{j \in S(i)} \frac{Imm_j}{d_{ij}^2}}$, where It_i is the number of Italians living in the neighborhood i; in the denominator we add to the immigrants living in the neighborhood i, *Imm*, those living in the surrounding neighborhoods. The weight $\frac{1}{d_{ij}^2}$ roughly approximates the probability of Italian residents of the neighborhood i to interact with foreign people of neighborhood j. Our assumption is that the city planner dislikes residential segregation, aiming at a even value of this ratio within the city. The resulting unidimensional index on the Ethnic variable can be safely interpreted as an exposure index. In this spirit, we consider as foreign residents ethnic groups more often subjected to discrimination, such as African, South-

[11] Blomquist (2006, p. 495) argued that "*... one Quality of Life index does not fit all...*" and hence it is a very hard task to carry out a comprehensive measure, which represents the preferences of the entire body of residents.

American or some Asian communities. Other immigrants - from, for example, North-America or West-Europe - have become invisible in Italy[12] and have been assimilated to Italian residents.

Finally, education is proxied by the distance to the nearest university (*Education*). Unfortunately, we do not have information on other variables for quality of education, such as the percentage of pupils moving up to a higher class or some indicators of classroom and/or building facilities.[13] We have rather information on the degree of availability of the different education levels, such as the number of primary and secondary schools in the neighborhood, both public and private. We have also data on early years of education, that is the number of nursery schools and preschools. We tried alternative specifications including these variables but none of these turns out to be statistically significative. There at least two reasons that can explain this result. First, the number of schools available in the neighborhood is a rough proxy of education services and it is not able to capture the quality of education services. Secondly, the variability of some of these covariates is quite modest across neighborhoods.

In addition to these amenities, we include the Euclidean proximity of each neighborhood to the city center to control for all amenities that have not been explicitly considered. We test the hypothesis of a monocentric structure of the urban area à la Alonso (1965) and Muth (1969) implying that housing prices increase with the proximity to the city centre since the quantity and variety of amenities increase too. Indeed, the urban pattern of Milan can be considered monocentric, since it is clearly identifiable by the old inner ring of inland waterways (*Navigli*) designed by Leonardo da Vinci. Outside the former ring, a second ring forms the circuit of the *Mura Spagnole*. Within the two rings are gathered the most important historical monuments (Duomo, Sforzesco Castle, Royal Palace, etc.) and outside, till the existing border of the municipality, large neighborhoods have been developed.[14]

Descriptive statistics are reported in Table 1. Amenity statistics embody the availability of amenities in the bordering zones, calculated introducing the distance function $f(d_{ij}) = d_{ij}^2$. The specification of f is consistent with gravitation models (White 1983, Batten and Boyce 1986,

[12] As in other Western countries, see for example Pan Ké Shon (2010) for France.

[13] For classroom facilities we intend, for example, modern teaching aids, air conditioned rooms, spacious rooms, and neat and clean rooms. The building facilities are, for example, recreation and gym facilities, high-speed internet access, an extensive library, and computer lab facilities.

[14] The residential housing market of the city reflects the monocentric basic models à la Alonso and Muth (see Michelangeli and Zanardi 2009).

Wong 1993), and following Marans (2003), the distance is expressed in miles. Amenities located in a surrounding neighborhoods at a distance less than or equal to a mile are added to that of the initial neighborhood, while those further apart than a mile are divided by d_{ij}^2.

< Insert Table 1 about here >

The average value for the 2,592 properties sold over the 2004 − 2008 period is 403,288 euro. This value is determined by transaction prices (30.43% of all transactions), offer prices (44.36%) and estimated values (25.19%). The average property has 95.72 m^2 of total floor area and is 48.28 years old at the time of sale. Each neighborhood has on average 12% of green over urban area with a substantial variability: from 1% in the Ronchetto-Chiaravalle-Ripamonti neighborhood at South-Ouest to 25% in the off-center neighborhood Monza Precotto Gorla located in the North. Also the number of the metro stations in the neighborhood is rather variable: from 0 to 12.9 metro stations. Each neighborhood has on average 9.44 commercial facilities and 5 cultural places per 10,000 inhabitants. Finally, the average ratio of foreign to Italian residents in the neighborhood is 9%; the minimum percentage is 3.22 and the maximum 21.26.

3.2 Estimated implicit prices

To obtain the full-implicit prices of location-specific amenities given in (5), we estimate a reduced form of the housing price hedonic equation

$$\ln p_{ht} = \alpha + \sum_{r=1}^{2} \beta_r m_{ir} + \gamma \ln S_h + \gamma \ln age_h + \sum_{p=1}^{P} \delta_p x_{hp} + \sum_{j=2}^{k} \rho_j \, l_{hj} + \sum_{\tau=2}^{T} \phi_\tau \, s_{h\tau} + \varepsilon_{ht}, \qquad (12)$$

where the logarithm of the price for any housing unit h sold at time t (with $t = 1, ..., T$) depends on:

- a constant term α,
- two dummy variables m_{h1} and m_{h2} equal to 1 if the price of the housing unit h is, respectively, an offer price and an estimated price and 0 otherwise. The reference value is the selling price,
- the logarithm of the size measured in square meters, $\ln S_h$,[15]
- the logarithm of the age of the building where the housing unit is located, $\ln age$,

[15] Diewert (2003) suggests to use the same functional form for the continous variable (i.e. the housing size) in order to test the hypothesis of constant returns to scale.

- a set of variables x_{hp} measuring other private characteristics of the housing unit,
- a set of variables l_{hj} describing the location amenities,
- a set of time dummies $s_{h\tau}$ equal to 1 if the housing unit is sold at time t and 0 otherwise,
- a residual term ε_{it} assumed to be normally and independently distributed across observations with zero mean.

3.3 Results

Table 2 presents the results obtained from estimating (12) with the set of independent variables we have mentioned in the previous paragraph. All in all, the housing variables used in the model account for about 87 percent of the variance of the logarithm of price. The amenity coefficients are statistically significant and to quantify their relative importance in our specification we present the standardized beta coefficients in column 3.[16]

< Insert Table 2 about here >

The most important amenity according to this criterion is *Green* since a one standard deviation increase in this variable implies 0.161 standard deviation increase in the value of the housing unit. A possible explanation of the statistical relevance of this variable is that it measures not only the extension of the available green areas, but also the facilities which are often located within gardens and parks (playgrounds for children, bicycle lanes and sports centers). The next amenity in terms of importance is *Cultural* (0.156). In this case, the importance could be explained by the location of some specific theaters and museums in ancient buildings whose households appreciate the aesthetic and artistic value. For example, the Museum of Ancient Art is in the Sforzesco Castle, probably the most famous monument together with the Duomo and the Scala Theatre. The other standardized beta coefficients are 0.048 for *Ethnic*, 0.042 for *Transport*, 0.025 for *Commercial facilities* and 0.011 for the proximity to the nearest university (*Proximity_ University*).

In addition to the amenities that we discussed so far, we include a number of house characteristics to control for housing heterogeneity. These estimates appear to be quite intuitive. On average, offer prices are 6 percent higher than market prices. The coefficient of the dummy variable for

[16] The standardized beta coefficient quantifies how many standard deviations change the house value when each control variable is increased a one standard deviation.

estimated market value is not statistically significant, so we conclude that in general evaluations formulated by the OMI officers are not too far from the actual transaction prices. The coefficient of the total floor area surface is less than 1, which means that the marginal price for an additional square meter decreases at a decreasing rate. As expected, a second bathroom or more, like the presence of a garage, positively influences the transaction price. A middle or high story apartment (2^{nd} floor or more) is better than a ground floor or first floor apartment. A flat to be renovated has a lower value than one in normal conditions. The type of building matters as does age.

The full implicit prices for each amenity are reported in Table 3, with *Cultural*, *Ethnic* and *Transport* showing the largest prices in absolute value. The hedonic price for an additional cultural place per $10,000$ inhabitants in the areal unit is $2,839$ euro; increasing by one point the percentage of the Italian/foreign ratio leads to an increase of $2,500$ euro in the value of the average housing unit value, and an additional metro station provides a benefit of $2,475$ euro. We have included the distance to the nearest university and it turns out that reducing the distance by 1 km increases the housing unit's value by $1,377$ euro. The estimated implicit price for an additional commercial facility per 10,000 inhabitants is $1,051$ euro and the lowest hedonic price is referred to the public green areas, with 612 euro for the marginal ha provided.

< Insert Table 3 about here >

Prices are much higher in the city center and decrease as the distance from the center increases. See Table A1 in the Appendix for an illustration of how quality of life changes across city neighborhoods.

In Table A1 and Figure A.2 we report the values of QOL and average income for each city neighborhood. Table A1 presents the QOL index values in the different neighborhoods of Milan and the map in Figure A2 allows to visualize their spatial distribution. All neighborhoods of the city centre have a value near to or by far exceeding 100,000 euro with the exception of the neighborhood 6 – Castello, Melzi d'Eril, Sarpi that has a value of 74,775 euro.[17] The lowest value is for the neighborhood 55 – Quarto Oggiaro, Roserio, Amoretti, developed in the Fifty to receive workers from the South Italy, in the course of time this neighborhood has taken a strongly negative

[17] This lower value is explained by the massive settlement in the last ten years of wholesale trading of clothing and leather goods managed essentially by the Chinese community. Moreover, the district is become place of conflicts between residents and wholesalers because of the continuous uploading and downloading items, which make difficult both the road traffic and the pedestrian crossing.

connotation due to the presence of the organized crime, to the decay of housing conditions and to the high percentage of irregular immigrants (over 4,000 apartments of public housing, 700 are illegally occupied). A correlation coefficient of 0.8458 between these two variables validates the results in Bruckner et al. (1999) on the importance of amenities in driving the location choice of rich households towards the better endowed neighborhoods. Our empirical results confirm the monocentric shape of Milan, characterized by a richer and more endowed city center.

According to the model we presented in Section 3, we calculate the weights $\boldsymbol{\sigma} = [\sigma_1, ..., \sigma_k]$ the social planner assigns to the set of amenities. The third column in Table 3 shows that the weights are fairly similar and that the lowest is assigned to the socioeconomic dimension *Ethnic.* This means that she results more adverse to the unequal distribution of ethnic groups across the neighborhoods than to the unequal distribution of the other amenities.

We recall that the equally distributed equivalent share γ associated to each amenity corresponds to the share of the average value citywide of each amenity such that, if equally distributed throughout all the area units would provide the same level of the evaluation function assessed with the actual distribution of the amenity within the city. It depends both on inequality aversion of the planner with respect to the distribution of a given amenity and on the degree of evenness in its distribution within the city. We find the highest values for *Ethnic* (0.930), followed by *Commercial Facilities* (0.867) and *Proximity University* (0.861), while *Green* (0.568), *Transport* (0.542) and *Cultural* (0.334) have lower equally distributed equivalent shares. Finally, we compute the interaction term κ slightly bigger than 1 ($\kappa = 1.091$),[18] implying that the joint effect of amenity distributions positively contributes to the overall QOL index.

The last step backward defines the extent of the reduction of the traditional QoL index *à la* Roback shown in (1). This value amounts to $71,473$ euro. The calculations carried out show that the overall equality measure is $\vartheta = 0.72$ and therefore the QOL index accounting for equity should be 72% of the value of $71,473$ euros computed before.

We conclude this section wondering whether our empirical results would still be meaningful if we adopted a needs-based criterion of equity in the city. Suppose for instance that households composed of people more than 65 years of age are concentrated in a few city neighborhoods. In this case it could be reasonable to concentrate amenities like health services in these neighborhoods. To investigate this point, we look at the distribution of two kinds of households with specific needs

[18]If κ would be equal 1, there was no joint effect of amenity distributions on QOL index.

(households with children and people more than 65 years old) in Milan. Since these households are evenly distributed across city neighborhoods (their Gini concentration index is respectively 0.056 and 0.068) we then conclude that our results are robust with respect to the demographic distribution of households.

4 Conclusions

We have proposed a new methodology to assess urban QOL, accounting for availability of amenities within the city. Our empirical results on Milan point out a high correlation between the level of availability of amenities and the income of households across city neighborhoods. This phenomenon has been explained in the setting of the NUE literature by Brueckner et al. (1999), in terms of high income elasticity of the willingness to pay for amenities. It follows that policies favoring an even availability of amenities should contribute to decrease stratification in the city, improving efficiency and equalizing opportunities and life-chances (Massey and Denton 1996).

Our analysis offers a suitable tool to assess the effects of gentrification and urban renovation (Helms 2003, Lees 2008, Barthélémy et al. 2007). Further empirical investigations could check the robustness of our results with respect to the Modifiable Areal Unit Problem due to the exogenous partition of the city (see Openshaw and Taylor 1979; 1981 or Nakaya 2000). Finally, from the theoretical side, we have considered the size and the distribution of the population within the city as fixed. To implement long-run analysis (Rosenthal 2008) one could set the problem of the city planner in terms of variable population ethical principles (Blackorby et al. 2005). This is an interesting avenue for further research.

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Variable	Mean	Std Dev	Min	Max	Unit
Housing value	403.3	409.9	80,000	7,000,000	Euro
Market_p	0.304	0.460	0	1	dummy
Offer_p	0.446	0.496	0	1	dummy
Estimated_p	0.251	0.434	0	1	dummy
Amenities					
Transports	4.36	3.31	0	12.90	continuous
Proximity_University	4.61	1.62	0	6.60	km
Green	12.04	5.24	1	25	%
Cultural	5.00	10.74	0.06	70.43	continuous
Commercial_Facilities	9.44	4.96	1.34	21.64	continuous
Ethnic	9.14	3.75	3.22	21.26	%

Table 1: Summary statistics for the variables

Variable	Mean	Std Dev	Min	Max	Unit
Housing characteristics					
Total floor area	95.72	46.01	19.00	452	m^2
Number of bathrooms	1.36	0.63	1	6	discrete
To be renoveted	0.042	0.200	0	1	dummy
Heating	0.124	0.330	0	1	dummy
2^{nd} floor (or higher)	0.817	0.386	0	1	dummy
Low_cost	0.538	0.498	0	1	dummy
Medium_cost	0.428	0.494	0	1	dummy
Luxury	0.032	0.178	0	1	dummy
Parking	0.019	0.067	0	1	dummy
Elevator	0.819	0.384	0	1	dummy
Age	48.2	21.9	1	205	discrete
Control variables					
City centre	0.15	0.35	0	1	dummy
Proximity_city centre	4.5	2.2	0.1	9.3	km
Year 2004 (ref.)	0.14	0.35	0	1	dummy
Year 2005	0.23	0.42	0	1	dummy
Year 2006	0.19	0.39	0	1	dummy
Year 2007	0.21	0.41	0	1	dummy
Year 2008	0.20	0.40	0	1	dummy

Table 1 (cont.): Summary statistics for the variables

Variable	Coefficient	t	beta
Intercept	10.6	273.9	-
Offer_p	0.062	4.51	0.048
Estimated_p	-0.007	-0.51	0.005
Amenities			
Transport	0.007	4.21	0.041
Proximity_University	0.004	1.05	0.011
Green	0.001	2.02	0.161
Cultural	0.009	11.72	0.155
Commercial_Facilities	0.003	2.31	0.025
Ethnic	0.008	5.84	0.048

Table 2: Hedonic regression

Variable	Coefficient	t	beta
Housing characteristics			
$\ln(tot\_area)$	0.940	67.07	0.662
Second bathroom	0.048	3.65	0.035
Third bathroom	0.093	3.49	0.027
To be renewed	-0.110	-4.85	-0.035
Heating	0.012	0.86	0.006
2^{nd} floor (or higher)	0.017	1.53	0.010
Medium cost	0.029	2.73	0.023
Luxury	0.116	4.21	0.032
Parking	0.154	3.33	0.023
Elevator	0.068	5.41	0.041
$ln(age)$	-0.006	-1.51	-0.018
proximity	0.0003	3.48	0.123
proximity squared	0.0000	1.83	0.077
Control variables			
City centre	0.104	4.16	0.059
Year 2005	0.040	2.72	0.027
Year 2006	0.108	7.08	0.068
Year 2007	0.101	6.09	0.663
Year 2008	0.104	6.03	0.067
Number of observations			2,592
$F(26; 2,565)$			672.84
Prob $> F$			0.000
R^2			0.8721
Adjusted R^2			0.8708

Table 2 (cont.): Hedonic regression

Variable	Hedonic price	Unit	σ	γ
Transport	2,475	Euro/station	0.1698	0.5418
Proximity_University	1,377	Euro/km	0.1822	0.8608
Green	612	Euro/ha	0.1794	0.5683
Cultural	2,839	Euro/place	0.1603	0.3339
Commercial_Facilities	1,051	Euro/place	0.1722	0.8671
Ethnic	2,500	Euro/$(it./for.)$	0.1360	0.9300
Parameter	**Value**			
Correlation term κ				1.0909
QOL_{ϑ}				0.72

Table 3: Hedonic prices and adjusted-QOL index

Appendix

Zone	Neighborhood name	Inhab.	Av. Income [€]	QOL [*Euro*]
1 - B11	Scala, Manzoni, Vittorio Emanuele, S. Babila	3,265	60,257	263,453
2 - B12	Brera, Duomo, Cordusio, Torino	7,712	61,387	146,553
3 - B13	Missori, Italia, Vetra, Sant'Eufemia	6,134	45,529	161,974
4 - B14	Diaz, Fontana, Europa	4,448	51,638	179,833
5 - B01	Cadorna, Monti, Boccaccio	6,493	57,335	130,176
6 - B02	Castello, Melzi d'Eril, Sarpi	24,478	30,850	74,775
7 - B03	Turati, Moscova, Repubblica	7,975	41,599	138,516
8 - B04	Venezia, Majno, Monforte	2,658	76,556	194,809
9 - B05	Mascagni, Porta Vittoria, Porta Romana	16,355	49,959	99,891
10 - B06	Porta Ticinese, Porta Genova, Magenta	18,958	33,647	103,477

Table A1: List of neighborhoods in Milan - Centre

Zone	Neighborhood name	Inhab.	Av. Income [€]	QOL [*Euro*]
11 - C01	Cenisio, Procaccini, Firenze	26,088	20,024	52.749
12 - C02	Fiera, Giulio Cesare, Sempione	19,756	28,289	77.183
13 - C03	Amendola, Monte Rosa, Buonarroti	17,566	32,762	74.483
14 - C04	Pagano, Monti, Wagner	8,448	44,901	107.130
15 - C05	Piemonte, Washington, Cimarosa	32,651	28,928	90.539
16 - C06	Solari, Napoli, Savona	10,757	23,921	101.283
17 - C07	Naviglio Grande, Argelati, San Gottardo	13,353	18,715	68.724
18 - C08	Tabacchi, Sarfatti, Crema	31,802	21,618	65.100
19 - C09	Libia, XXII Marzo, Indipendenza	52,173	22,264	56.482
20 - C10	Regina Giovanna, Pisacane, Castel Morrone	22,410	26,847	90.670
21 - C11	Abruzzi, Eustachi, Plinio	22,906	26,321	106.415
22 - C12	Stazione Centrale, Gioia, Zara	50,087	22,457	82.059

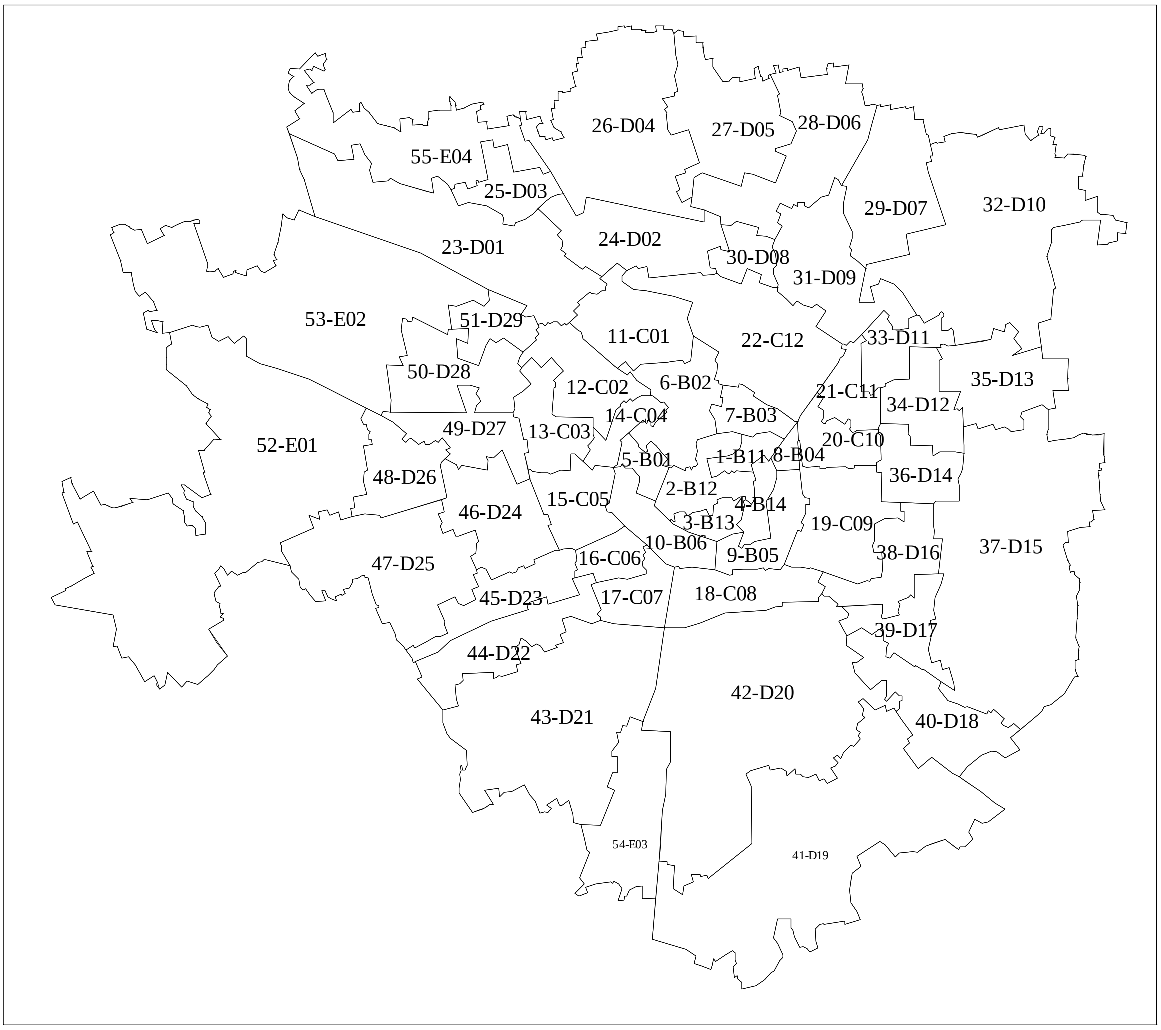
Table A1 (cont.): List of neighborhoods in Milan - Mid-centre

Zone	Neighborhood name	Inhab.	Av. Income [€]	QOL [*Euro*]
23 - D01	Musocco, Varesina, Certosa	36,200	14,740	35,251
24 - D02	Bovisa, Bausan, Imbonati	32,519	14,595	42,884
25 - D03	Largo Boccioni, Aldini, Lopez	15,514	11,887	35,848
26 - D04	Bovisasca, Affori, P. Rossi	43,240	14,335	40,679
27 - D05	Niguarda, Ornato	25,397	14,411	51,490
28 - D06	Fulvio Testi, Bicocca, Ca' Granda	26,694	15,885	62,749
29 - D07	Monza, Precotto, Gorla	30,814	15,458	50,086
30 - D08	Zara, Istria, Murat	14,361	16,034	52,883
31 - D09	Loreto, Turro, Padova	51,457	16,813	69,693
32 - D10	Parco Lambro, Feltre, Udine	56,571	14,993	47,346
33 - D11	Aspromonte, Porpora, Teodosio	26,259	19,721	67,789
34 - D12	Leonardo da Vinci, Gorini	19,303	20,247	65,149
35 - D13	Lambrate, Rubattino, Folli	6,768	16,518	42,878
36 - D14	Argonne, Viale Corsica	27,318	20,777	59,496
37 - D15	Forlanini, Mecenate, Rogoredo	32,255	14,540	34,697
38 - D16	Ortomercato, Molise, Piranesi	12,071	18,783	50,896
39 - D17	Boncompagni, Toffetti, Bacchiglione	11,933	17,235	41,159
40 - D18	Omero, Gabriele Rosa, Brenta	20,996	13,447	34,283
41 - D19	Ronchetto, Chiaravalle, Ripamonti	12,158	17,404	37,389
42 - D20	Montegani, Cermenate, Vigentino	45,664	16,991	49,032
43 - D21	Barona, Famagosta, Faenza	46,458	14,761	50,401
44 - D22	San Cristoforo, Ronchetto, Ludovico il Moro	22,260	12,360	55,367
45 - D23	Giambellino, Tirana, Frattini	27,723	16,396	45,903
46 - D24	Siena, Tripoli, Brasilia	42,150	19,313	66,706
47 - D25	Lorenteggio, Inganni, Bisceglie	41,657	14,848	50,972
48 - D26	Novara, San Carlo, Amati	9,704	14,729	47,383
49 - D27	Segesta, Capecelatro, Aretusa	29,543	16,204	46,154
50 - D28	Ippodromo, Caprilli, Monte Stella	5,070	27,664	91,340
51 - D29	Cagnola, Achille, Papa, Tiro Segno	5,826	19,907	52,780

Table A1 (cont.): List of districts in Milan - Outlying

Zone	**Neighborhood name**	**Inhab.**	**Av. Income [€]**	**QOL** [*Euro*]
52 - E01	Baggio, Quinto Romano, Quarto Cagnino	45,757	14,107	36,115
53 - E02	Gallaratese, Lampugnano, Figino	44,020	18,652	66,154
54 - E03	Missaglia, Chiesa Rossa, Gratosoglio	20,624	12,595	40,792
55 - E04	Quarto Oggiaro, Roserio, Amoretti	17,894	11,791	30,096

Table A1 (cont.): List of districts in Milan - Suburbs



(13)

Fig. A.1: Map of Milan

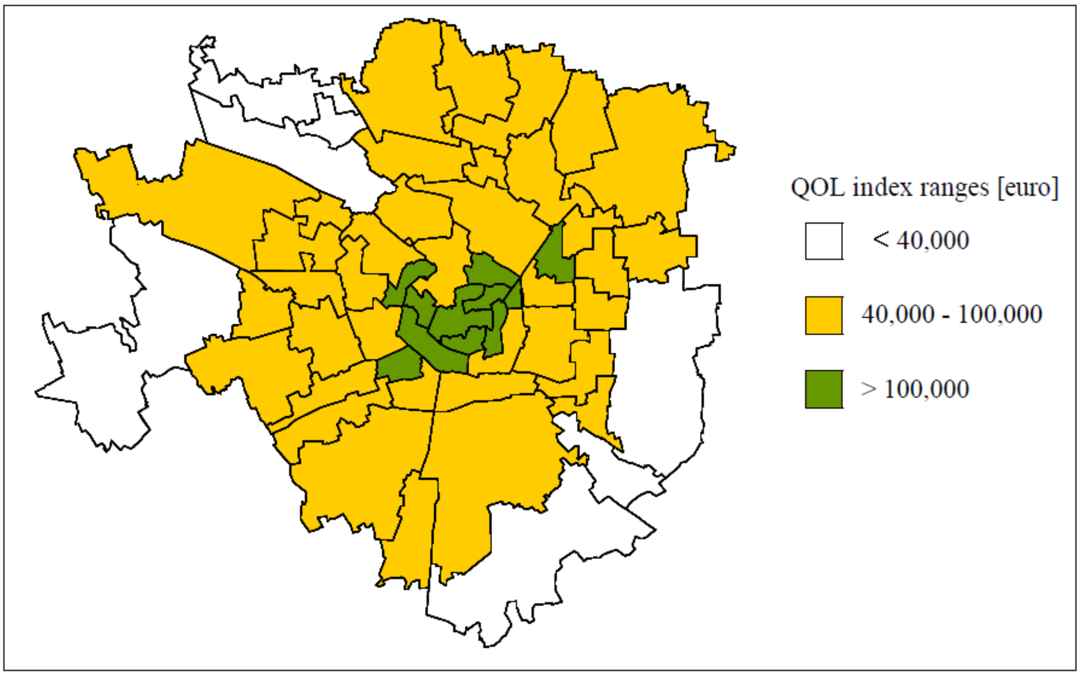


Fig. A.2: QOL across neighborhoods

(14)

Variable	Definition	Source
Market_p	1 if the housing value is a market price (ref.)	OMI
Offer_p	1 if the housing value is an offer price	OMI
Estimated_p	1 if the housing value estimated by OMI	OMI
	Private characteristics	
$\ln(tot\_sur)$	logarithm of the total floor surface	OMI
Second bathroom	1 if the unit has a second bathroom, or more	OMI
Third bathroom	1 if the unit has a third bathroom, or more	OMI
To be renewed	1 if the unit needs to be renewed	OMI
Heating	1 if the unit has gas central heating	OMI
2^{nd} floor (or higher)	1 if the unit is on second floor, or higher	OMI
Low cost	1 if the unit is in a low cost building (ref.)	OMI
Medium cost	1 if the unit is in a medium cost building	OMI
Luxury	1 if the unit is in a luxury building	OMI
Parking	1 if the unit has at least one parking space	OMI
Elevator	1 if the unit is in a building with an elevator	OMI
Age	age of housing unit	OMI
Distance	distance of the unit to the centre	Authors' computation
City centre	1 if the unit is one of the zones in the centre	OMI
	Amenities	
Transport	number of metro stations	Milan Transport Agency
Proximity_University	proximity to the nearest university	Authors' computation
Green	percent of public green areas	Milan Municipality
Cultural	cultural places[1] per 10,000 inhabitants	Milan Municipality Yellow Pages
Commercial_Facilities	commercial facilities[2] per 10,000 inhabitants	Authors' computation
Ethnic	Italian/Foreign	Milan Municipality

[1] Cinemas, theatres, museums, art galleries, academies of music and libraries.

[2] Supermarkets, discount stores and malls.

Table A.2: Variable description

Elenco Quaderni già pubblicati

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2. L. Giuriato, *Mutamenti di regime e riforme: stabilità politica e comportamenti accomodanti*, settembre 1993.
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