DEPARTMENT OF ECONOMICS, MANAGEMENT AND STATISTICS

UNIVERSITY OF MILAN – BICOCCA

DEMS WORKING PAPER SERIES

How Does a City Benefit from Culture? Evidence from Milan

Riccardo Borgoni, Alessandra Michelangeli, Nicola Pontarollo

No. 335 – May 2016

Dipartimento di Economia, Metodi Quantitativi e Strategie di Impresa
Università degli Studi di Milano - Bicocca
http://dems.unimib.it/

How Does a City Benefit from Culture? Evidence from Milan[§]

Riccardo Borgoni[*] Alessandra Michelangeli[$] Nicola Pontarollo[°]

May, 2016

Abstract

Cultural amenities are the expression of a cultural environment, given by a combination of aesthetics factors, styles, rhythms, behaviours, which contribute to make vibrant and more enjoyable a neighbourhood. Within the theoretical framework of the hedonic approach, we propose an empirical strategy to capture the multiple effects of cultural amenities. The results are used to determine whether cultural amenities are optimally provided by the municipality of Milan. It turns out that government should devote far more resources to culture.

Key Words: culture; city; hedonic approach; multilevel models.

JEL Codes: R11; R12 ; R23.

[§] Financial support by the Italian Ministry of University and Research is gratefully acknowledged. The authors gratefully acknowledge the Real Estate Observatory for housing market data. We thank Stefano Barberis and Sherony Warnakulasuriya for excellent research assistance. The usual disclaimer applies.

[*] DEMS -University of Milan-Bicocca, Piazza dell'Ateneo Nuovo 1, 20126 Milan (Italy). E-mail address: riccardo.borgoni@unimib.it

[$] DEMS - University of Milan-Bicocca, Piazza dell'Ateneo Nuovo 1, 20126 Milan (Italy). E-mail address: alessandra.michelangeli@unimib.it

[°] DEMS - University of Milan-Bicocca, Piazza dell'Ateneo Nuovo 1, 20126 Milan (Italy). E-mail address: nicola.pontarollo@unimib.it

1. Introduction

Cultural amenities play an important role in enhancing economic and social development of the community where they are located.[1] As regard to economic contribution, cultural amenities create jobs, attract businesses, and generate incomes that are subsequently spent locally by visitors and staff. The local government benefits from more taxes on income and sales. As regard to social contribution, cultural amenities attract high-human capital individuals and improve neighborhood conditions with their buildings, facilities and initiatives, such as cultural events open to all. In addition to the large variety of effects of economic and social nature, cultural amenities can involve the demographic structure, or the economic system or again the infrastructure system of a local community. Some of these effects can be highly interrelated and generate secondary effects in the long run. For example, the installation of a performing art centre can induce a local government to strengthen public transport to facilitate access to the centre. This can increase the number of visitors at the art centre, more people will attend the neighborhood where the center is located, consumption will be higher and this can have an impact upon the creation of jobs, business and other leisure activities (retail, restaurants, hotels) contributing to transform that neighborhood. As Sheppard (2010) observes, cultural organizations and arts activities sometimes provide benefits to world culture and to all of us, independently of where beneficiary resides.

This paper focuses on the local effects of cultural amenities in the city of Milan, which has long been considered the Italian cultural capital because of cultural and creative production (Sacco, 2012). We develop an empirical strategy based on the hedonic approach applied to the housing market. In the last decades, few studies have followed this approach to value cultural amenities at the neighborhood or city level. For example, Clark and Kahn (1988) use a two-stage hedonic wage

[1] This has been recognized amongst the principles underpinning the European Union in Treaty of Maastricht (EC, 1992) and in the Lisbon Treaty (EC, 2007). In artt. 128 and 167, respectively, the two Treaties report that: "the Community shall contribute to the flowering of the cultures of the Member States, while respecting their national and regional diversity and at the same time bringing the common heritage to the fore" (EC 1992, art. 128; EC 2007.art. 167).

model to estimate the social benefits of cultural amenities in a large number of US cities in the '80s. Moro et al. (2013) estimate several specifications of a hedonic price equation to establish whether distance to, and density of, cultural heritage sites are capitalized into housing prices in Greater Dublin, Ireland. Sheppard (2013) examines both theoretically and empirically the impact of the opening or expansion of museums on their neighborhoods using the hedonic approach applied to the residential housing market.

We contribute to the literature on cultural amenities in several important ways. First, we start by considering that cultural amenities constitute an element of something, which is hard to measure. We refer to the "cultural environment", generated by a combination of aesthetics factors, styles, rhythms, behaviours. Under this perspective, cultural amenities are important not only *per se*, but also because they contribute to make vibrant a neighbourhood, and perhaps more thoughtful and tolerant. We try to capture all these aspects by proposing a new measure for cultural amenities named Cultural Filter and inspired to the concept of Social Filter introduced by Rodríguez-Pose (1999) and developed by Rodríguez-Pose and Crescenzi (2008) in innovation literature. The Social Filter is a composite index combining relevant socio-economic variables aiming at identifying the unique combination of factors that make a territory more likely to innovate (Rodríguez-Pose and Villareal, 2015). Second, the paper shows how geocoded information can provide enormous advantages for socio-economic modeling. Geocoding allows to combine information from a range of different sources, such as *ad hoc* surveys, administrative or census records, or cartographic information, often freely downloadable from the web. The resulting dataset contains an amount of extremely detailed information which is not usually available in urban studies. In addition, this allows to investigate the phenomenon of interest at very local detail where the socio-economic dynamics are of great interest but difficult to grasp. Third, at the best of our knowledge, we are the first to attempt to determine whether cultural amenities are optimally provided by comparing costs and benefits associated with them.[2]

The remainder of the paper is structured as follows. Section 2 introduces the theoretical framework. Section 3 describes the data. Section 4 discusses the empirical strategy. Section 5 presents the results and provides a cost-benefit analysis to assess whether the provision of cultural amenities are sufficiently founded. The last section concludes.

2. Theoretical Framework

We consider a city partitioned into N neighborhoods, indexed by n, with a population of I perfectly mobile, price-taking households, indexed by i. Households dispose of income $\boldsymbol{m} = (m_1, \dots, m_I)$ and have preferences over two consumption goods: a numéraire composite good, denoted by x, and a unit of housing. Each unit of housing is characterized by a K-dimensional vector of objectively measurable housing-specific characteristics and amenities, $\boldsymbol{z} = (z_1, \dots, z_K) \in {}^{K}_{+}$, including culture. We denote by $\boldsymbol{D}$ the closed and convex set of all conceivable packages of the K housing-specific characteristics and amenities.

Households' preferences over the composite good and housing are represented by an increasing and strictly concave utility function $U_i(\boldsymbol{z}, x)$, characterized by a decreasing marginal rate of substitution between goods along an indifference surface. Let $P(\boldsymbol{z})$ be the observed equilibrium price schedule associated with the housing unit with characteristics $\boldsymbol{z}$. The optimal bundle $(\boldsymbol{z_i}, x_i)$ maximizes the utility of household i subject to the budget constraint and corresponds to the solution of the following problem:

$$\max_{(\boldsymbol{z},x)\in R_+^K} U_i(\boldsymbol{z}, x) \quad \text{s.t. } m_i \geq P(\boldsymbol{z}) + x. \tag{1}$$

[2] A previous work of one of the authors (Gravel et al., 2006) used the theoretical framework to evaluate some public programmes aimed at reducing school failure in poor cities located in France, near Paris.

First order conditions for the internal solution $(\boldsymbol{z_i}, x_i)$ imply the following set of equations:

$$\frac{\partial P(\boldsymbol{z}_i)}{\partial z_{ij}} = \frac{U_i(\boldsymbol{z_i}, x_i)_{z_{ij}}}{U_i(\boldsymbol{z_i}, x_i)_x}, \quad \forall j = 1, \dots, K \tag{2}$$

$$P(\boldsymbol{z}_i) = m_i \quad \boldsymbol{z}_i,$$

where $U_i(\cdot)_{z_{ij}}$ is the marginal utility of household i associated with amenity z_j, and $U_i(\cdot)_x$ is the marginal utility of household i associated with the numéraire. At the optimum, the marginal rate of substitution between z_j and the numéraire is equal to the marginal willingness to pay of household i for an additional amount of z_j.

We denote the household i's indirect utility function by $V_i(\widehat{m}_i)$, where $\widehat{m}_i$ is defined below. Household utilities are aggregated into a social welfare function expressed in formal terms as $W = W\big(V_1(\widehat{m}_1), \dots, V_I(\widehat{m}_I)\big)$. Social welfare function is continuously differentiable and increasingly monotonic. The distribution of observed incomes across households, denoted by $(\widehat{m}_1, \dots, \widehat{m}_I)$, is assumed to be optimal with respect to the social welfare function, i.e. $(\widehat{m}_1, \dots, \widehat{m}_I)$ are the solution of the following program:

$$\max_{(m_1,\dots,m_I)} W\big(V_1(m_1), \dots, V_I(m_I)\big) \text{ s.t. } \textstyle\sum_{i=1}^{I} m_i \leq \sum_{i=1}^{I} \widehat{m}_i. \tag{3}$$

As observed in Gravel et al. (2006), the hypothesis of optimal distribution of observed incomes implies to assert that the actual income distribution is considered "just" or socially optimal.

The social value of a marginal increase in amenity j quantity is given by:

$$\frac{\partial W}{\partial z_j} = \sum_{i=1}^{I} \frac{\partial W\big(V_1(\widehat{m}_1), \dots V_I(\widehat{m}_I)\big)}{\partial V_i} \cdot \frac{\partial V_i(\widehat{m}_i)}{\partial m_i} \cdot \frac{\partial P(\boldsymbol{z}_i)}{\partial z_{ij}} \cdot dz_j \tag{4}$$

The optimality of income distribution implies that $\frac{\partial W(V_1(\widehat{m}_1),\dots V_I(\widehat{m}_I))}{\partial V_i}$ is equal to the Lagrange-Kuhn-Tucker multiplier associated with the constraint $\sum_{i=1}^{I} m_i \leq \sum_{i=1}^{I} \widehat{m}_i$. in the maximization problem (3). Thus, equation (4) approximately reduces to:

$$\frac{\partial W}{\partial z_j} = \sum_{i=1}^{I} \frac{\partial P(z_i)}{\partial z_{ij}} \cdot dz_j, \quad \forall j = 1, \dots, K. \tag{5}$$

In section 6, we show how we use the model presented above to determine whether cultural amenities are optimally provided by comparing the amount of public investments in cultural amenities with the estimated benefits associated with them.

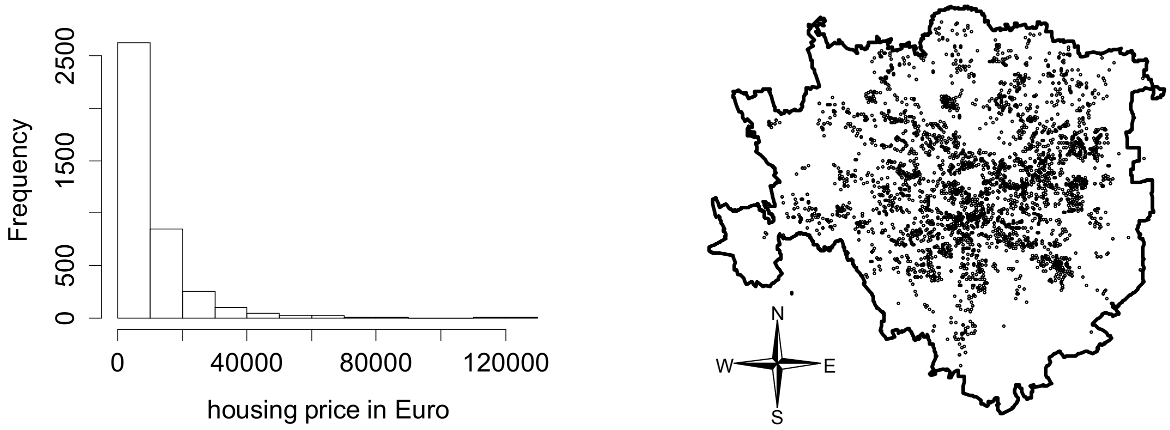
3. Data and Variables

In this paper several datasets have been joined together to obtain the information used in the next sections for the empirical analysis. There are two main sets of data, namely housing market data and amenity data.

Housing market data consists of 3946 housing transactions occurred in Milan between 2004 and 2010. The dataset is provided from the Real Estate Observatory (*Osservatorio del Mercato Immobiliare*),[3] which divides the city of Milan in 55 administrative areas[4] (henceforth neighborhood) on the basis of housing market behavior: the division is such that prices of houses located in the same neighborhood are supposed to move together. A simple descriptive analysis presented below shows a great variability of housing prices across neighborhoods. Transaction prices were converted in annual rents by applying a discount rate specific to each neighborhood, as in Andreoli and Michelangeli (2014). The discount rate was determined by dividing the average imputed rent by the average price of housing in the neighborhood, both expressed in constant 2010 Euro. Housing units in the sample are spatially identified by the civic address. We geocoded each civic address in the dataset by its UTM coordinates using a Java script that retrieves this information from Google Maps geographical databases. Figure 1, panel *(a)* shows the sample distribution of

[3] http://www.agenziaentrate.gov.it/wps/content/nsilib/nsi/documentazione/omi accessed March 31, 2016.
[4] See Figure 7.

housing prices and panel *(b)* the spatial locations of the housing units included in the sample.



*(a)** *(b)*

*mean = €11,550, std.dev. = €12,339, range = (€3,600; €129,500).

Figure1: *(a)* sample distribution of market values; *(b)* spatial locations of the sample properties

Figure 2 shows the boxplots of housing prices by neighborhood and confirms that there exists a large heterogeneity in the price distribution between neighborhoods that we will take into account to model price dynamics appropriately.

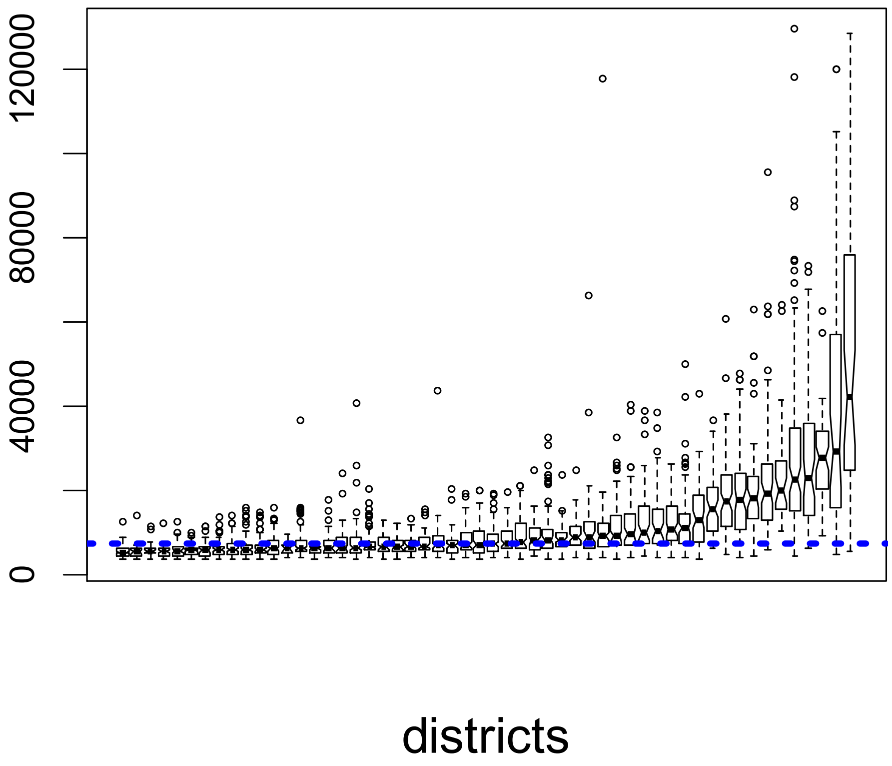


Figure 2: boxplots of property prices conditioned to neighborhood.
The dashed horizontal line represents the sample median.

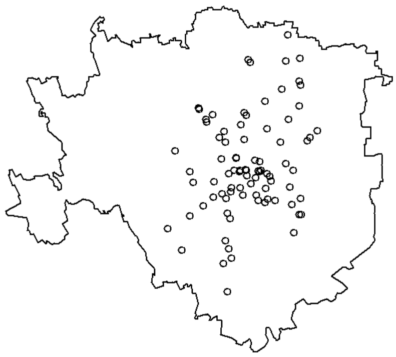
In addition to housing market values, the data set provides a detailed description of housing-specific attributes of the sample units, including total floor space, floor level, number of bathrooms, whether the housing unit has independent heating, presence of an elevator or a garage. A more detailed description of these variables is reported in Appendix.

We retrieved geo-coded data about amenities from the open data portal of the municipality of Milan.[5]

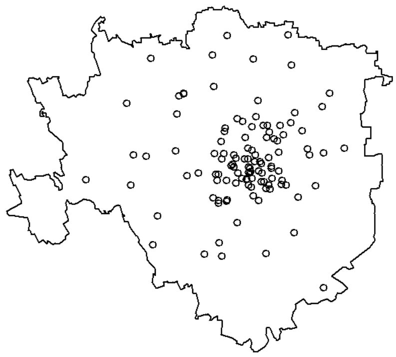
Figure 3 depicts spatial locations of different amenities. In particular we considered 88 theaters, fig. 3-(*a*), 117 libraries, fig. 3-(*b*), 78 museums, fig. 3-(*c*), 189 conference centers, fig. 3-(*d*), 139 parks fig. 3-(*e*) and 710 university sites, fig. 3-(*f*). The latter figure also shows the stops of the metro lines. Green areas correspond to public parks for which the area is specified in hectares by the municipality of Milan and are spatially located at their centroids. Maps reported in figure 3 depict

[5] dati.comune.milano.it accessed March 31, 2016.

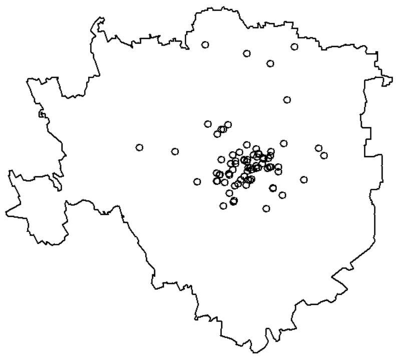
a clear clustering towards the city center for all the considered amenities, with the exception of parks and university sites.



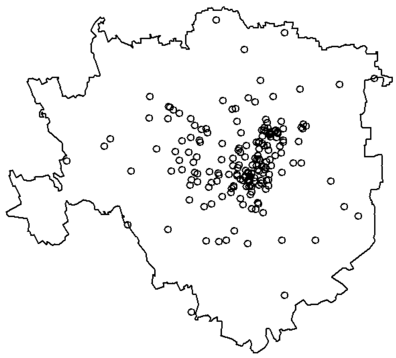
(a) Theaters



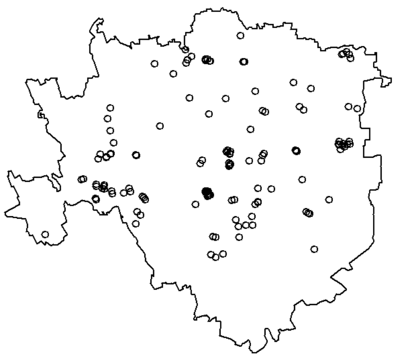
(b) Libraries



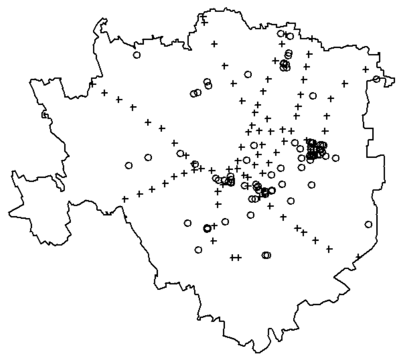
(c) Museums



(d) Conference centers



(e) Parks



(f) Universities (dots) and metro stops (crosses)

Figure 3: Spatial location of urban amenities in Milan

4. Empirical Strategy

The empirical strategy adopted in this paper is based on the multilevel approach. Multilevel analysis (Goldstein, 2011; Snijders and Bosker, 1999) is a methodology for the analysis of data with complex patterns of variability. Hierarchical modeling is conveniently carried out by resorting to mixed-effects models (McCulloch and Searle, 2001) i.e. statistical regression models which incorporate both fixed effects (that are constant across groups), and random effects (that randomly vary across groups). By associating common random effects to observations in the same group, mixed-effects models flexibly represent the covariance structure induced by the grouping of data. Multilevel models have been employed in several works on the hedonic approach applied to the housing market, where houses are considered as nested in neighborhoods and the analysis is carried out at individual house level and neighborhood level simultaneously (Goodman and Thibodeau, 1998; Orford, 2000 and 2002; Brown and Uyar, 2004; Gelfand et al., 2007). This kind of models allows to dissect group-level and individual-level effects on individual-level outcomes, i.e. the property prices, accounting for the non-independence of observations within groups, i.e. the neighborhoods. A common problem with observations nested within a higher level is that there may be a problem of dependencies because individual properties in the same district are likely to be similar in ways not fully accounted for by the property and district variables included in a single-level model (Jones and Bullen, 1993). Multilevel models allow to accommodate the spatial dependency of the residuals by differentiating between-individual errors from between-neighborhood errors (Orford, 2000). If this dependency is not considered, the standard error estimates turn out to be biased (Snijders and Bosker, 1999).

4.1. Model Specification

We partially recall the notation introduced in Section 2. City neighborhoods are denoted by n, with

$n = 1, \ldots, N$; housing units are indexed by , with $= 1, \ldots, H$. There are H_n housing units in neighborhood n, and $\sum_{n=1}^{N} H_n = H$. The hedonic price equation is specified as a random intercept model as follows:

$$ln(P_{hn}) = \beta_0 + \boldsymbol{\beta'}_1 \boldsymbol{X}_{hn} + \boldsymbol{\beta'}_2 \boldsymbol{Z}_{hn} + A_n + \varepsilon_{hn}, \tag{6}$$

where P_{hn} is the market value of housing unit in neighborhood n; $\boldsymbol{X}_{hn}$ is a column vector of housing characteristics and $\boldsymbol{Z}_{hn}$ is a column vector of amenities of housing unit h in district n; A_n is the random intercept representing level 2 (neighborhood specific) residuals. ε_{hn} are level 1 (housing unit specific) residuals. They are assumed to be mutually independent and normally distributed with zero mean and variance equal to σ^2. Level 2 residuals are assumed to be uncorrelated with ε_{hn}, mutually independent and normally distributed with zero mean and variance equal to τ^2. ε residuals represent the unexplained variability of the (log) selling price of housing units after considering measurable characteristics of the property and the district clustering, whereas A residuals represent unexplained heterogeneity at the district level. The latter allows to deal with the problem of spatial sorting on unobservable (Gyourko et al., 1999). This occurs when high-quality housing units are located in the best city neighborhoods and the factor determining the high-quality of houses and neighborhoods are unobservable. This point will be returned to section 5.

It straightforwardly turns out that $Var(log(P_{hn}) \mid \boldsymbol{X},\boldsymbol{Z}) = \sigma^2 + \tau^2$. Hence the overall conditional variability of price can be decomposed in two components due to individual and district heterogeneity: $\tau^2 \,/\, (\sigma^2 + \tau^2)$. This is known as the intraclass correlation coefficients, representing the proportion of variability due to district clustering and measuring the correlation shared by units within a neighborhood.

The model has been estimated by restricted maximum likelihood using the R function `lmer` of library `lme4` (Bates et al. 2015).

In the next two sections we show how urban amenities are measured. The variables we obtain enter in vector $\boldsymbol{Z}_{hn}$ of (6).

4.2. Construction of the amenity covariates

The construction of amenity covariates follows Tobler's (1970) first law of geography stating that '*everything is related to everything else, but near things are more related than distant things*' (Tobler 1970, p. 237). Accordingly, amenities influence housing prices in function of the distance between them and housing units: housing prices decline with distance in the case of an amenity and increase with distance in the case of disamenity. Moreover, housing prices also depend on the quantity and/or size of amenities, positively in case of amenities, negatively in case of disamenites. We use a measure able to catch these two aspects of amenities: their distance from the houses and their size or quantity.

The measure is based on the potential accessibility indicator, developed by ESPON (2007) and Osland (2010), and is composed of two functions: the amenity function measuring the size or quantity of amenities, and the impedance function measuring the distance between housing unit and amenity (Wegener et al., 2002). Formally, the variable measuring accessibility of amenity z_j is $\tilde{z}_j$ defined as:[6]

$$\tilde{z}_j = \sum_{s=1}^{S_j} w_{js} \exp(\ \ \gamma\, d_{hjs}), \qquad (7)$$

where S_j is the total number of amenity z_j locations; w_{js} is the amenity function defined below; $\exp(\ \ \gamma\, d_{hjs})$ is a distance decay function, d_{hjs} being the Euclidean distance expressed in meters between housing unit h and amenity z_j located in s.

[6] To avoid cumbersome notation, in what follows we drop the subscript indicating neighborhood *n*. We also do this below when the context alone suffices to identify the data hierarchy.

The amenity function w_{js} for green areas corresponds to their size in hectares. For all the other amenities – metro, theatres, museums, libraries, congress centers – we have not got appropriate amenity dimensions, hence the amenity function has been constantly set to 1 (i.e. $\tilde{z}_j$ is a weighted total of the amenity in the study areas).

The advantage of using the variable $\tilde{z}_j$ is that it accounts not only for the closest amenity, but also for the farther ones, weighting them according to their distances from housing units. The value of parameter γ affects the "shape" of impedance function and it has been endogenously determined on the basis of the lowest Akaike Information Criterion (AIC) of the estimated regression model. More specifically, the accessibility index in equation (7) was evaluated over a grid of γ values and the log-price was marginally regressed on each of these indices in turns, separately for each amenity. The γ value providing the lowest AIC was retained to build the covariates used in the regression model (6). The γ values obtained are reported in Table 1.

Table 1: γ values and the radius of influence of each considered amenity

Variable	Parks	Metro	Theatres	Museums	Libraries	Congress centres
γ	0.0085	0.0057	0.0047	0.0193	0.0127	0.0187
Radius of influence (metres)	460	680	820	200	300	210

Figure 4 shows the shape of the impedance function for the two more extreme cases: museums (highest γ value in table 1) and theaters (smallest γ value in table 1). The impedance function gives a smaller weights to an amenity the farther its location to a housing unit, hence when the value of the impedance function gets negligible, the impact of this amenity location vanishes.

In Osland's (2010) work-job accessibility is considered as labor-market opportunity, observing a positive relationship between housing prices and access to labor markets. In our framework the accessibility index in equation (7) will convey information regarding the effects of the surrounding both in term of infrastructural and cultural amenities. A numerical example can clarify this point. Suppose we have a housing unit with three metro stations located at 200 meters, 500 meters and

1000 meters respectively. The estimated γ is equal to 0.0057 (see table 1), hence the potential accessibility is:

exp(−0.0057×200)+exp(−0.0057×500)+exp(−0.0057×1000) = 0.3198+0.0568+0.0033 = 0.3810. In this case the nearest metro station determines 84% of the value of the indicator whereas the farthest metro station only contributes 1% although all the three stations are encompassed by the index. Setting a conventional distance threshold one can worked out a "radius of influence" of any given amenity i.e. a distance above which the impedance function is virtually 0 implying that the contribution of the corresponding locations is negligible. Using, for example, a threshold equal to 0.02, the radius of influence of the metro stations is 680 meters.

The case of parks is slightly different since we weighted the impedance function by the size of parks. Suppose, as before, that there are three parks located at 200 meters, 500 meters and 1000 meters with a size respectively of 0.6 hectares, 2 hectares and 20 hectares. In this case $\gamma = 0.0085$, and the potential accessibility is:

exp(−0.0085×200)×0.6+exp(−0.0085×500) ×2+exp(−0.0085×1000) ×20 = 0.1422. Interpreting this value is less straightforward than in the previous case since it depends on the number of parks and their size. The radius of influence of the other amenities are summarized in Table 1.

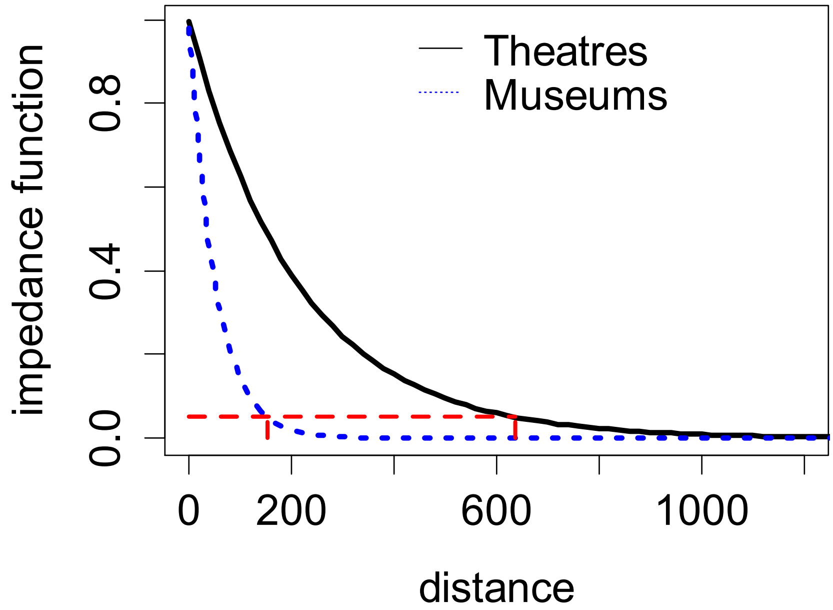


Figure 4: The impedance function for different γ and the influence radius obtained by inverting the impedance function

As regards effects induced by higher-education institutions on housing prices, we follow a slightly different procedure to measure them. In Milan there are 710 university buildings belonging to seven main institutions and four academies of arts and design.[7] As shown in panel *(f)* of Figure 3, these institutions are not concentrated in some area but are spread across neighborhoods. Making residence choice, a potential dweller considers the proximity to a specific higher-education institution, rather than to a variety of different institutions because the latter are far from each other. For this reason, we consider the following proximity index defined for housing unit h as $\frac{\max_u(d_{hu})-d_{hu}}{\max_u(d_{hu})}$, where d_{hu} is the distance between the housing unit h and the university site u; the maximum is calculated with respect to all the 710 university sites. The descriptive statistics of

[7] The seven universities are: Bocconi University; Catholic University of the Sacred Heart; International University of Languages and Media; Milan-Bicocca University; Politechnic of Milan; San Raffaele University; University of Milan. The four academies are: Brera Fine Arts Academy; European Design Institute; New Fine Arts Academy; SAE Institute Milan.

amenity covariates are shown in Table A1 of the Appendix.

4.3. The cultural filter

One of the main challenges of the paper is to identify a variable for cultural amenities able to capture the multiple effects of these amenities mentioned in the Introduction. We develop a measure, named Cultural Filter, which is a composite indicator of the cultural amenities available in our dataset: theatres, museums, libraries and congress centres. These amenities are expected to grasp the cultural environment of a neighborhood in line with the literature on metropolitan cultural districts. Santagata defines a metropolitan cultural district "*a spatial agglomeration of buildings dedicated to performing art, museums, and organizations which produce culture and related goods services and facilities*" (Santagata 2002, p. 12). If the cultural amenities are next to each other, they are likely to form a network able to generate greater socio-economic effects. Cooke (2008) states that interactions between cultural institutions or, more generally, between actors in cultural government generate a 'synergetic surplus' "*enabling the actions or projects of individuals to yield much more value from being part of a larger programme*" (Cooke 2008, p. 28). In this paper, we are not strictly evaluating the effects of metropolitan cultural districts on housing prices nor the effects of some cultural network. We aim to make a step ahead evaluating if culture amenities, which considered alone might lose their "self-reinforcing power", are able to affect housing values by themselves, without necessarily being clustered in a cultural district.

To obtain the cultural filter, we first construct the accessibility index for the four cultural amenities according to equation (7). The accessibility indexes turn out to be moderately correlated to each other, the correlation coefficients ranging between 0.29 and 0.47. Hence, a natural way to get a unique variable out of them it is to resort to a principal component (PC) analysis (Rodriguez-Pose, 1999). More specifically, we performed a PC analysis via a singular value decomposition of the correlation matrix of the four accessibility indexes. Only the largest eigenvalue has been found significantly larger than 1, whereas the others have values ranging from 0.73 to 0.43. The first PC alone explained more than 50% of the total inertia, whereas the others explained the same minor proportion of the total variability. Then, the first PC has been used as a synthetic indicator of cultural amenities and named Cultural Filter in the paper. Using the first PC has also the advantage to reduce multicollinearity in the linear predictor of the regression model assuring more stability to the numerical procedures used in model fitting and avoiding, at the same time, to subset the amenities set that can lead to lose or underestimate their network effect on housing prices. The loadings of the first PC are: 0.50 (theatres), 0.50 (museums), 0.55 (libraries) and 0.45 (congress centres). Since these values are quite similar, the four typologies of cultural amenities are equally represented by the cultural filter.

Figure 5 shows the spatial dynamic of the cultural filter predicted across the city. The map reveals how large values of the filter are expected towards the city centre. To spatialize the filter a regular grid of 1138 points has been created within the boundary of Milan municipality provided by a shapefile. For each of these points the accessibility index in equation (7) has been calculated with respect to the locations of the four cultural amenities mentioned above obtaining a 1138×4 matrix. The first PC has been predicted by multiplying this matrix by the first eigenvector of the correlation matrix. Figure 5 has been obtained by rasterizing the grid.

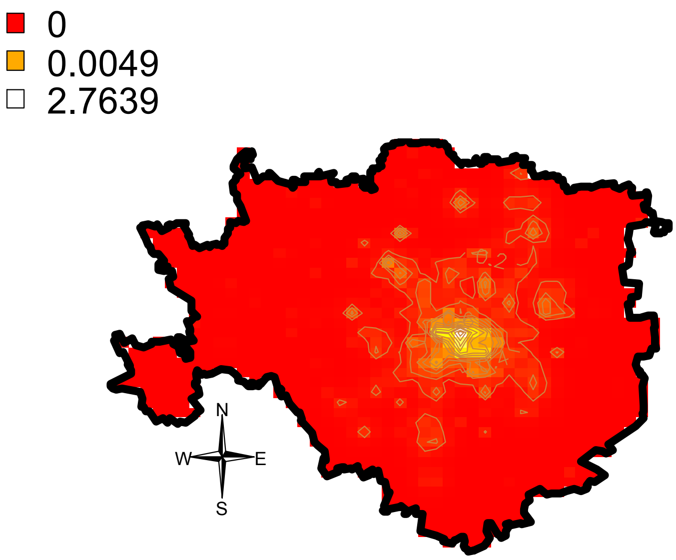


Figure 5: Cultural filter map

5. Results

In this section the regression results are presented. The covariates entered in the model by block, as shown in table 2. Model 1 includes the constant term and the intercept random term; Model 2 adds the group of time fixed effects; model 3 adds housing specific characteristics; model 4 also considers amenities other than the cultural filter and model 5 includes the cultural filter. The overall housing (log)-price variability is estimated as big as 0.4423 by Model I. 57 per cent of this variability is due to neighborhoods' factors whereas 43 per cent is explained by housing-specific factors. Adding variables to the baseline model 1, the variance of random effects decreases of more than an half, meaning that the additional explanatory variables are able to explain a relevant portion of variability in log price. More specifically, housing-specific characteristics decreases unexplained variability of 50.1 per cent; urban amenities reduce unexplained variability of 13.6 per cent; and the cultural filter further reduces variability of 11.3 per cent.

As it can be noticed, all covariates behave in a priori predictable way. Focusing on amenities variables, they are all significant at different levels. Proximity to university, parks and metros positively contribute to determine the equilibrium housing price. The estimated coefficients associated with the polynomial term for the cultural filter indicate that the impact of culture is increasing at a decreasing rate. This means that cultural amenities have a stronger positive effect when they are few or less accessible and their effect reduces if their quantity increases or they become more accessible

	Model 1	Model 2	Model 3	Model 4	Model 5
			Random effects variances:		
District	0.25360	0.25460	0.12706	0.10974	0.09728
Residual	0.18870	0.18700	0.05866	0.05777	0.05759
			Fixed effects estimates:		
Intercept	9.11025 *** (0.06892)	9.12888 *** (0.07141)	8.16100 *** (0.05296)	7.89800 *** (0.06484)	7.89900 *** (0.06296)
Housing area			0.01024 *** (0.00026)	0.01031 *** (0.00025)	0.01029 *** (0.00025)
Housing area^2			-0.00001 *** (0.00000)	-0.00001 *** (0.00000)	-0.00001 *** (0.00000)
Floor>1			0.02292 *** (0.00863)	0.02174 ** (0.008568)	0.02258 *** (0.008557)
Lift			0.02764 ** (0.01093)	0.02641 ** (0.01086)	0.02678 ** (0.01084)
Auton. heating sys.			0.02714 ** (0.01283)	0.02864 ** (0.01274)	0.02822 ** (0.01272)
Parking area			0.14860 *** (0.04106)	0.15620 *** (0.04076)	0.15300 *** (0.0407)
More than one bath			0.11050 *** (0.01153)	0.10790 *** (0.01145)	0.10920 *** (0.01144)
Parks				0.1554 *** (0.03583)	0.14920 *** (0.03585)
Metro				0.06491 *** (0.02204)	0.04053 * (0.02276)
Univ.				0.30000 *** (0.05065)	0.27700 *** (0.05088)
Cultural filter					0.02923 *** (0.00773)
Cultural filter^2					-0.00134 * (0.00074)
2005		0.00403 (0.02624)	0.02156 (0.01475)	0.02138 (0.01464)	0.02242 (0.01462)
2006		0.04625 * (0.02688)	0.05624 *** (0.01513)	0.05623 *** (0.01502)	0.05840 *** (0.01501)
2007		0.02252 (0.02675)	0.02927 * (0.01507)	0.02904 * (0.01495)	0.02867 * (0.01493)
2008		-0.04713 * (0.02703)	0.00098 (0.01525)	0.00139 (0.01513)	0.00066 (0.01511)
2009		-0.07530 *** (0.02676)	-0.03401 ** (0.01509)	-0.0342 ** (0.01498)	-0.03226 ** (0.01497)
2010		-0.07341 *** (0.02635)	-0.04371 *** (0.0149)	-0.04277 *** (0.01479)	-0.04232 *** (0.01477)
Nb of obs.	3946	3946	3946	3946	3946

Table 2: hierarchical linear model estimates

The hedonic prices or marginal willingness to pay (MWTP) associated with urban amenities are reported in table 3.[8] As shown in Section 2, they correspond to the partial derivative of the estimated hedonic price function. To calculate the derivative, first the estimated expected price is obtained by equation (6). However, since the log transformation of the prices under the Gaussian assumption of the residuals has been considered, the relation between the normal and the lognormal distribution has to be taken into account for deriving appropriate estimates. The following results from the normal distribution are used. If Y is a normally distributed random variable with expected value μ and variance ϑ^2, $P = \exp(Y)$ is lognormally distributed with expected value equal to $\exp(\mu + \vartheta^2/2)$. The multilevel regression model in equation (6) provides the estimate of μ conditional on the values of the covariates on the log scale and the estimates of the two additive components, σ^2 and τ^2, of ϑ^2. Hence, the expected value of the price has been obtained by plugging in the estimated values in the previous formulas.

In order to compare the relative size of the effects of different amenities, the hedonic prices are computed considering a marginal variation in the corresponding amenity equal to 1 standard deviation, keeping all the other covariates at the average sample quantities.

Amenity	MWTP
Cultural filter	225
University	549
Metro	134
Parks	275

Table 4: hedonic prices of amenities

The hedonic price associated with cultural filter indicates that households are, on average, willing to pay 225 Euro per year for a marginal increase of the filter.

Table 4 shows the estimation results of model (6) where the Cultural Filter components are introduced separately.[9] All the filter components are statistically significant at 0.01 level, with the exception of

[8] Hedonic prices for housing-specific characteristics can be provided upon request.
[9] The complete estimation results for each specification are available upon request.

theaters, which are significant at 0.1 level. Accessibility indexes for museums and congress centers admit a polynomial term implying nonlinear effects on housing log-prices. According the hedonic price associated with each component, the accessibility index for museum is the most important component of the Cultural Filter (€889), followed by congress centers (€502), libraries (€297), and theatres (€200).

	Model 6	Model 7	Model 8	Model 9
Theatres	0.02602 *			
	(0.01355)			
Museums		0.75130 ***		
		(0.18090)		
Museums^2		-1.5130 ***		
		(0.37180)		
Museums^3		0.61760 ***		
		(0.16330)		
Libraries			0.1425 ***	
			(0.03549)	
Congress centres				0.27020 ***
				(0.08512)
Congress centres^2				-0.21490 **
				(0.09911)
Contol var.	*yes*	*yes*	*yes*	*yes*
N° of obs.	3946	3946	3946	3946
AIC	375.355	367.056	361.043	369.228

Significance: *** 1%, ** 5%, * 10%.

Table 5: hierarchical linear model estimates for the filter components

It is worth emphasizing two further results. The first one concerns the intercept random term, whose estimates, based on model 5, are reported in Figure 6. Substantial variations can be observed across neighborhoods, the intercept term varies between -0.4274 and 0.9324 and the standard deviation is equal to 0.3103. The positive values mainly refer to neighborhoods located in the city centre, while negative values are rather in the outlying neighborhoods. This term allows to handle the problem of the spatial sorting mentioned in Section 4.

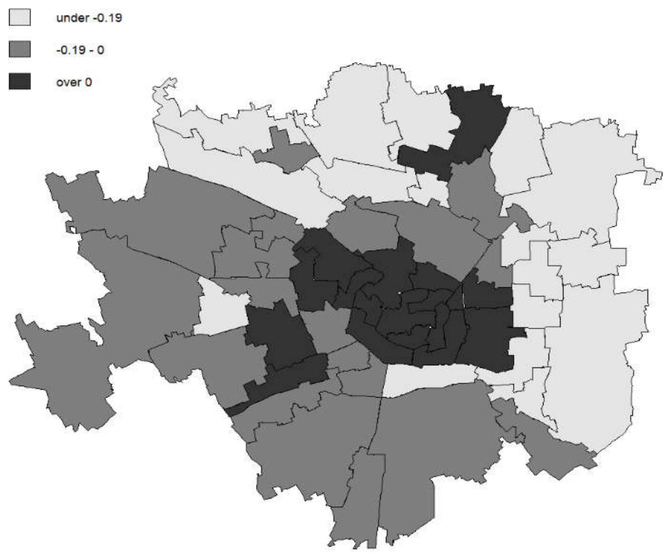


Figure 6: random effect estimates

The second comment concerns the MWTPs calculated by neighborhood for each amenity, and reported in see Figure 2. MWTPs tend to be higher in the city centre and lower in the neighborhoods far from the city centre. This is consistent with the positive sorting in which households with high MWTP avoid poor-endowed neighborhoods to live in the best-endowed amenities.

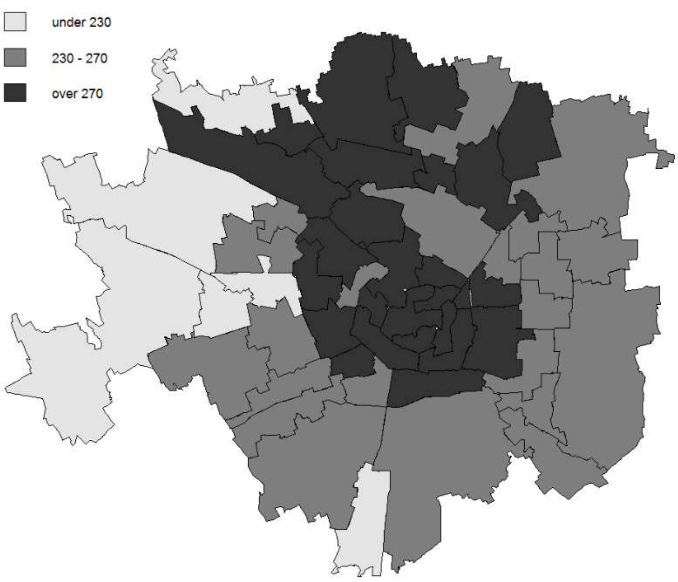


Figure 7: marginal willingness to pay by neighborhood for cultural filter

We use equation (5) to compute the social benefit associated with a marginal increase in the cultural filter. The social benefit is obtained summing up the MWTP over the number of city's residents, which is on average equal to 1,305,508 inhabitants in the period 2004-2010. In the computation we consider the total population because cultural amenities are also enjoyed by children. The MWTP represents an approximation of amenity benefits for the younger groups of population, and, accordingly, the estimation of the social benefit, equal to 295million Euro, has to be taken with a grain of salt. Annual investments in culture over the same period amount to about 35million Euro,[10] an average of €27 Euro per person versus a MWTP of €225. This leads us to conclude that the municipality of Milan allocates too few resources to culture with respect to the expected benefits. According our results, the city's governments should spend 8 times more. This result is in line with figures for 2010 provided by Eurostat and published by the European Commission (2012) according to which Italy ranks last in culture expenditures, 1.1 of public expenditures versus an average 27-EU equal to 2.2 per cent.

7. Conclusion

This paper is an original attempt to measure the local effects of cultural amenities through the observation of the housing market. Starting from the premise that cultural amenities affect a community in many ways, we propose an innovative measure for cultural amenities, named Cultural Filter, which fully exploits the available statistical information about museums, libraries, congress centers and cultural associations. Cultural Filter and other urban amenities considered in our analysis

[10] The municipality balance sheet and relative income and expenditure items are available on line http://www.openbilanci.it Accessed March 31, 2016.

are constructed in such a way of not considering only the nearest quantity of a given amenity but all the quantities of each amenity weighted by the inverse of distance.

The empirical findings show that cultural amenities have a positive effect on housing prices, and the strongest filter components are museums and cultural associations.

The results provide interesting insights for policies aiming at improving the quantity and quality of cultural amenities. We show the amount of public resources currently devoted to cultural activities are much smaller than the social benefits produced by this kind of amenities. Cultural amenities, if organized in cultural districts, as defined by Santagata (2002), create the conditions for economic activities attracting not only artists and artisans, but also highly educated full-time employed people[11], revitalizing urban spaces. In the case of Milan, the evidence related to the effect of cultural amenities increasing with their density is in line with the results of Ponzini (2009), who finds that also in the case of Mount Vernon Cultural District, there is a steadily rise in real estate prices. The importance of culture in urban development is also stressed by EU commission in EU2020 perspective because recognized able to create spill-over effects to other vital economic sectors. This belief, that induced in 2015 the Commission to plan the creation of a composite indicator that will monitor cultural and creative initiatives at city level in the EU (see: https://ec.europa.eu/jrc/en/news/creative-and-cultural-industries-impact-cities), has been proved in our study, where we demonstrate that this intuition was correct.

[11] For example, a large survey of about half a million individuals in Germany shows that the highly educated full-time employed respondents, who moved in the last 10 years, rank "cultural offerings and an interesting cultural scene" among the top five reasons for their location choice (Buettner and Janeba, 2016).

References

Andreoli, F.,and Michelangeli, A. (2014) "Welfare Measures to Assess Urban Quality of Life", Working Paper n. 278, University of Milano-Bicocca, Department of Economics.

Bates, D., Maechler, M., Bolker, B., Walker, S., (2015) "Fitting Linear Mixed-Effects Models Using lme4", *Journal of Statistical Software*, 67(1), 1-48.

Brown, K.H. and Uyar, B. (2004) "A hierarchical linear model approach for assessing the effects of house and neighborhood characteristics on housing prices", *Journal of Real Estate Practice and Education*, 7(1), 15-23.

Buettner T and Janeba E. (2016) "City Competition for the Creative Class", *Journal of Cultural Economics*, forthcoming.

Clark, D.E. and Kahn, J.R. (1988) "The social benefits of urban cultural amenities", *Journal of Regional Science*, 28, 363-377.

Cooke P. (2008) "Culture cluster, district and culture quarters some reflection in the scale question", in Cooke P. and Lazzeretti L. (eds.) *Creative Cities, Cultural Clusters and Local Economic Development*, Northampton, Edward Elgar.

ESPON (2007). Update of selected potential accessibility indicators (Final report). Dortmund, Spiekermann & Wegener: http://www.espon.eu/export/sites/default/Documents/Projects/ESPON2006Projects/ScientificBriefingNetworking/UpdateOnAccessibilityMaps/espon_accessibility_update_2006_fr_070207.pdf

European Commission (1992) "Treaty on the European Union", *Official Journal C 191*, 29 July 1992.

European Commission (2007) "Treaty of Lisbon", *Official Journal C 306/1*, 17 December 2007.

European Commission, Directorate-General for Economic and Financial Affairs (2012) "The Quality of Public Expenditures in the EU", Occasional Papers, n. 125, 1-66.

Goldstein, H. (2011) *Multilevel statistical models*, Chichester, Wiley.

Gelfand, A.E., Banerjeeb, S., Sirmans, C.F., Tu, Y., and Ong, S.E. (2007) "Multilevel modeling using spatial processes: Application to the Singapore housing market", *Computational Statistics & Data Analysis*, 51, 3567-3579.

Goodman, A.C., and Thibodeau, T.G. (1998) "Housing market segmentation", *Journal of Housing Economics*, 7, 121-143.

Gravel, N., Michelangeli, A., Trannoy, A. (2006) "Measuring the social value of local public goods: An Empirical Analyis within Paris Metropolitan Area", *Applied Economics*, 38, 1945-1961.

Gyourko, J., Kahn, M. and Tracy, J. (1999) Quality of life and environmental comparisons, in:P. C. Cheshire and E. S. Mills (Eds) Handbook of Regional and Urban Economics, Vol. 3, 1413–1454. Amsterdam: Elsevier.

Helbich M., Brunauer W., Vaz E., Nijkamp P. (2014) "Spatial Heterogeneity in Hedonic House Price Models: The Case of Austria", *Urban Studies*, 51(2), 390-411.

Helbich M., Griffith D.A. (2015) "Spatially varying coefficient models in real estate: Eigenvector spatial filtering and alternative approaches", *Computers, Environment and Urban Systems*, 57, 1-11.

Helbich M. (2015) "Do suburban areas impact house prices?" *Urban Studies*, 42, 431–499.

Jones, K., and Bullen, N. (1993) "A multi-level analysis of the variations in domestic property prices", *Urban Studies*, 30(8), 1409-1427.

McCulloch, C.E. and Searle, S.R. (2001) *Generalized, Linear and Mixed Models*, Wiley, New York.

Moro, M., Mayor, K., Lyons, S. and Tol, R.S.J. (2013) "Does the Housing Market Reflect

Cultural Heritage? A Case Study of Greater Dublin", *Environment and Planning A*, 45, 2884-2903.

Osland L. (2010) "Spatial variation in job accessibility and gender: an intraregional analysis using hedonic house-price estimation", *Environment and Planning A*, 42, 2220-2237.

Orford, S. (2000) "Modelling spatial structures in local housing market dynamics: A multilevel perspective", *Urban Studies*, 37(9), 1643-1671.

Orford, S. (2002) "Valuing locational externalities: A GIS and multilevel modelling approach", *Environment and Planning B: Planning and Design*, 29(1), 105-127.

Ponzini D (2009) "Urban implications of cultural policy networks: the case of the Mount Vernon Cultural District in Baltimore", *Environment and planning C*, 27(3), 433-450.

Rodríguez-Pose, A. (1999) "Innovation prone and innovation averse societies. Economic performance in Europe", *Growth and Change*, 30(1), 75-105.

Rodríguez-Pose, A., and Crescenzi, R. (2008) "R&D, spillovers, innovation systems, and the genesis of regional growth in Europe", *Regional Studies*, 42(1), 51-67.

Rodríguez-Pose, A. and Villareal P. (2015) "Innovation and Regional Growth in Mexico: 2000–2010", *Growth and Change*, 46(2), 172-195.

Sacco, P.L. (2012) "Culture and the Structural Funds in Italy", EENC working paper, 1-65.

Santagata W. (2002) "Cultural districts, property rights and sustainable economic growth", *Journal of Urban and Regional Research*, 26(1), 433-450.

Sheppard, S. (2010) *Measuring the impact of culture using hedonic analysis*, Technical Report, Center for Creative Community Development, Department of Economics, Williams College, MA.

Sheppard, S. (2013) "Museums in the neighborhood: the local economic impact of museums", in Giarratani, F. and Hewings, G.J.D., and McCann, P. (Eds) *Handbook of Industry Studies and Economic Geography*, ch. 7, 191-204.

Snijders, T. A.B. and Bosker, R.J., (1999) *Multilevel Analysis*, Sage, London.

Tobler, W. (1970) "A computer movie simulating urban growth in the Detroit region", *Economic Geography*, 46(2), 234-240.

Wegener, M., Eskelinnen, H., Fürst, F., Schürmann, C., Spiekermann, K. (2002) "Criteria for the Spatial Differentiation of the EU Territory: Geographical Position", *Forschungen* 102.2, Bonn: Bundesamt für Bauwesen und Raumordnung.

Appendix

Housing characteristics considered in the model are described hereafter. Summary statistics are shown in Table A1.

Total housing area: it represents the total housing area in square meters. As suggested by Figure. A1, we expect this relationship is not linear, i.e. there is a decreasing marginal increase of price with housing size. Hence, we include a square term in the empirical specification of the hedonic price equation to catch this nonlinear pattern.

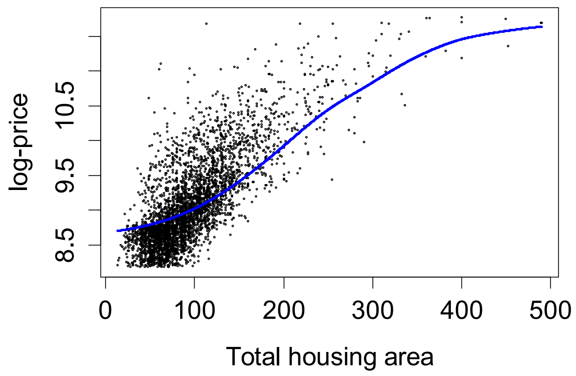


Figure A1: scatterplot of house prices on the log-scale versus the total housing

Floor: it is measured by a dummy variable equal to 1 whether the housing unit is located at the second floor or above, 0 otherwise. Milan is a highly densely populated city where the majority of housing units are apartments. Single houses or villas are not frequent (about 30 units) and we removed them from our dataset.

Lift: it is a dummy variable equal to 1 whether the building where the apartment is located has at least one lift, 0 otherwise.

Autonomous heating system: heating system can be autonomous or centralized. Centralized heating system was typical in Italy until the first nineties and consists of a unique thermal system for heating managed by the administrator of the building and the cost of heating are shared amongst co-owners. Apartments located in more modern buildings have an autonomous heating system we introduce in the specification a dummy variable equal to 1 whether housing units has an autonomous heating system, and 0 otherwise from the others. This variable also provides indirect information on the age of building (as in Helbich et al., 2014; Helbich, 2015; Helbich and Griffith, 2016), as very few apartment buildings with centralized heating system adopted the new system.

Parking place: it is measured by a dummy variable equal to 1 whether the housing unit has a parking place or garage, 0 otherwise. The presence of a private parking place or garage in Milan is not granted. Here, as many other big cities, parking places or garages are often sold separately from housing units.

Bathroom: we introduced in the specification of the hedonic price equation a dummy variable equal to 1 whether the apartment has two or more bathrooms (28% of the sample), 0 otherwise.

Year: we considered fixed effect per year from 2005 to 2010 (2004 is the reference year).

Variable	Measure	Mean	Std.Dev.	Min.	Max.	Freq.	Number
Cultural amenities and other urban amenities							
Theatres	distance from houses	4,458	2,279.17	8.18	14,64		88
Museums	distance from houses	4,030	2,064	3.9	14,50		78
Librares	distance from houses	4,437	2,309	3.32	15,44		117
Congress centers	distance from houses	4,358	2,2682	5.39	16,69		189
Parks	hectares	0.1064	5.4606	0.011	58.57		139
	distance from houses	5,433	2,724	27.42	17,45		139
Metro	distance from houses	5,432	2,814	11.11	17,9		87
Univ.	distance from houses	4,808	2,545	9.98	16,69		710
Housing-specific characteristics							
Annual market value	annual value in € 2010	11,554.51	12,338.57	3,600	129,509.2		3946
Housing area	square meters	95.50	48.40	13	490		3946
Lift	dummy			0	1	0.820	3946
Parking area	dummy			0	1	0.009	3946
More than 1 bath	dummy			0	1	0.275	3946
Floor>1	dummy			0	1	0.692	3946
Auton. heating sys	dummy			0	1	0.127	3946
Sold in 2004	dummy			0	1	0.155	3946
Sold in 2005	dummy			0	1	0.139	3946
Sold in 2006	dummy			0	1	0.144	3946
Sold in 2007	dummy			0	1	0.138	3946
Sold in 2008	dummy			0	1	0.143	3946
Sold in 2009	dummy			0	1	0.143	3946
Sold in 2010	dummy			0	1	0.153	3946

Distances from houses is in meters

Table A1: Summary statistics of amenities and housing-specific characteristics