Location and real estate values: a study for the segmentation of the Microzones of Turin

*Alice Barreca
**Rocco Curto
***Diana Rolando

Location and real estate values: a study for the segmentation of the Microzones of Turin

DOI: 10.14609/Ti_1_17_2e

Keywords: **Real estate market, listing prices, hedonic model, Turin, Microzones, Historical Territorial Units.**

Abstract The city of Turin is segmented in 40 cadastral Microzones, approved by the City Council in June 1999, which are set up as independent segments of the real estate market. Eighteen years have passed since the approval of the division of the city into homogeneous spatial segments, a period of time in which the pattern of the city has changed, both on the level of urban planning and due to the important changes in the real estate market, most notably the economic-financial crisis which has led to a steady decrease of prices from 2010 to date. Over the past few years, prior to upgrading the Microzones, the Turin Real Estate Market Observatory (TREMO) conducted a series of studies including the segmentation of the Microzones in Historical Territorial Units (HTU), identified on the basis of a historical-urban analysis of the area without questioning the boundaries of the Microzones. The purpose of this article is to illustrate the HTUs and to examine the contribution that a territorial unit smaller than the Microzone can give to the explanation of property prices, taking into account that when decreasing the territorial extension, one has to manage even less representative data samples.

In order to study the explanatory capacity of the positional variable, together with a series of variables related to the features of the apartments and buildings in the price determination process, a hedonic model was applied by using a sample of housing units offered on the market during the four-year period 2013-2016. In particular, starting from the territorial segmentation of the Microzones in the HTUs, a traditional hedonic model was applied: in the first application, the Microzone positional variable was assumed, whereas in the second, the HTUs were adopted.

Both applications generated significant results, with a high coefficient of determination (Adjusted R^2) and an excellent explanatory capacity of the variables considered. The importance of the "location", taken into consideration through the Microzones or through the HTUs, is historically recognized even at an international level and continues to be one of the most important features in the listing price determination process, even during the crisis period of the real estate market.

* Research fellow, Department of Architecture and Design, Politecnico di Torino

** Professor, Department of Architecture and Design, Politecnico di Torino

*** Full-time Academic Researcher Law 240/10 Art.24-A, Department of Architecture and Design, Politecnico di Torino

INTRODUCTION

The importance of the positional factor in the property price determination process is well known and is well-founded in several studies (Curto *et al.*, 2012; Semeraro and Fregonara, 2013; Curto *et al.*, 2015; Curto *et al.*, 2017a). Empirical evidence emerged from international literature with a particular focus on the importance of the spatial component of prices (Basu and Thibodeau, 1998) which led to the introduction of statistical spatial models for the study of the real estate market (Pace *et al.*, 1998) and the development of hedonic models, capable of measuring the influence on the prices of the spatial component represented by the territorial units in which the territory is segmented (Goodmane Thibodeau, 1998; Goodman and Thibodeau, 2003; Bourassa *et al.*, 2003; Bourassa *et al.*, 2007; Bourassa *et al.*, 2010).

Particularly when analysing the case of Turin, several studies confirmed that location is one of the characteristics that can mainly influence the property value, together with the building typology and its preservation status (Curto and Fregonara, 2013). In these studies, the positional factor of housing units was explained through the Microzone.

The city of Turin is segmented into 40 cadastral Microzones, approved by the Municipal Council in June 1999 in accordance with DPR 138/98 and the Regulation issued by the Ministry of Finance (Regulation on the rules for the General Review of Census Areas, estimated rates of urban housing units and relevant criteria and Census Commissions in implementation of Article 3, paragraphs 154 and 155 of Law n. 662 of 23 December 1996). The Microzones, defined by the Politecnico di Torino on the basis of a two step methodology, identify territorial units that are homogeneous with regard to town planning and at the same time constitute real segments of the real estate market.

The first phase of the methodology provided for the identification of descriptive indicators of the positional, urban, historical-environmental and socio-economic aspects of the urban area, while, the second phase entailed the consolidation of the set of variables based on further synthetic strategic indicators representing the influence of a large-scale infrastructure and valuable hubs – identified by prestigious urban areas - through the development and use of econometric models applied with descriptive purposes (Curto, 2005).

Eighteen years have passed since the approval of the division of the city into homogeneous spatial segments, a period of time in which the pattern of the city has changed, both on the level of urban planning and due to the important changes in the real estate market, most notably the economic-financial crisis which has led to a steady decrease of prices from 2010 to date.

The 40 Microzones of the city of Turin made up the segmentation of the urban area under real estate submarkets on the basis of which both the Turin Real Estate Market Observatory (TREMO)[1] (Curto and Fregonara, 2016) and the Observatory of the Real Estate Market of the Revenue Agency (OMI) have processed and analysed the information on the real estate urban market. Since 2015, the OMI has partially revised the boundaries of this territorial segmentation, so that to date, OMI areas no longer coincide with the Microzone census (cadastral districts).

1 Founded in 2000, the TREMO is active thanks to the collaboration between the Politecnico di Torino and the Municipality of Turin, with the primary objective to monitor the real estate values of the urban areas in which the city of Turin is segmented (Scientific Director: Prof. Rocco Curto; Scientific Co-Director: Prof. Elena Fregonara; Website: www.oict.polito.it/en).

In recent years, within the activities of the TREMO, the working group of the Politecnico di Torino conducted a number of studies that may be considered a prerequisite for the updating of the Microzone boundaries. These include the study conducted in 2011, on the segmentation of Microzones in the Historical Territorial Units (HTU), on which the analyses described in this article are based. It is pointed out that 93 HTUs were identified on the basis of a historical-urban interpretation of the urban area without questioning the boundaries of the Microzones.

Based on the assumption that this territorial segmentation with a historical imprint can also be useful for analysing the current building heritage system of values, the purpose of this article is to illustrate the HTUs of Turin and to examine the contribution that a territorial unit smaller than the Microzone can give to the explanation of property prices, taking into account that when decreasing the territorial extension, one has to manage even less representative data samples (Bates, 2006).

To this end, starting with the territorial segmentation of the Microzones in the HTUs, a hedonic model was applied on a sample of housing units listed on the market in the four-year period between 2013-2016 in order to study the explanatory power of the positional variable, together with a series of variables related to the features of the housing units and buildings in the price determination process. It is pointed out that the purpose of the analysis is not predictive, but it has mainly methodological and descriptive purposes. Specifically, a traditional hedonic model was applied: in the first application, the "Microzone" positional variable was assumed, whereas in the second one, the “HTU” was adopted. Starting from such premises, the following paragraphs illustrate the methodological approach used for the segmentation of the Microzones and the related 93 HTUs, followed by the hedonic model, the data sample used and the results achieved.

SEGMENTATION OF THE MICROZONES OF THE CITY OF TURIN IN HISTORICAL TERRITORIAL UNITS

Methodological approach

The study for the segmentation of the 40 Microzones of the city of Turin was conducted within the scope of the activities of the TREMO in 2011.[2] As above-mentioned, the goal was to divide the 40 Microzones into segments without altering their boundaries, by defining their smaller territorial units, so as to better represent the physical-typological and historical structure of the buildings that best describes the plurality of urban landscapes embedded in various historical directions and matrices, over time (Bor-Ming, 2012).

The methodological approach developed by the Politecnico di Torino was based on the following operative steps:

1) building up the information and knowledge base to support and build a foundation for the segmentation activity (Integration of the Land Information System - LIS - established by the TREMO with dedicated databases);

2) data input and verification of the information base on the listed assets with respect to various sources, Fund Managers, normative references;

2 The study on the segmentation of Microzones into Historical Territorial Units (HTU) was conducted by the TREMO working group from the Politecnico di Torino in collaboration with Prof. Cristina Cuneo, then lecturer at the II Faculty of Architecture, Politecnico di Torino.

3) identification of recurring and prevailing typologies of heritage buildings and building units;

4) analysis of urban planning, through investigations and technical-regulatory verifications;

5) testing starting from the already built up information base and the analyses produced in the previous stages of work, in order to identify the homogeneous territorial units from a historical-urban planning point of view.

In line with the objectives and operational steps outlined, the architectural and urban pattern of each Microzone was thoroughly studied in order to highlight the main urban factors, existing restrictions, environmental and architectural characteristics.

- urban factors: urban planning and infrastructures often attributable to the presence of main axes and historical roads; the presence of built-up plots with various levels of accessibility in relation to the centre of the city;
- municipal restrictions:[3] the presence of historical building units and the presence of listed assets (or currently under evaluation) in accordance with Art. 10 of Decree-Law n. 42 of 22 January 2004 (Code of Cultural Heritage and Landscape), which also includes listed assets in accordance with the former Law n. 1089 of 01 June 1939 (Protection of items of artistic and historical interest – implemented by Consolidated Law); location of the property within or adjacent to areas of paleontological interest, to monuments, or property of a particular historical-artistic value, areas placed under environmental restriction, to areas subjected to hydrogeological constraints in accordance with the existing law;
- environmental characteristics: location in solitary or inverse slopes (so-called "shadow cones"); location of the properties within or adjacent to forest areas, unrestricted passage areas; green (open) space; by streams; areas with a high level of geological-environmental risk, lithology and litho-geophysics of the soil (geology of ore deposits) and levels of land sliding;
- architectural characteristics: morphology of built-up plots and their distribution characteristics; building typology which is closely related to the various buildings' construction periods; Intended use of the property and the areas in which these are located (tertiary, commercial, residential, agricultural, schools); intended use of the relevant property spaces.

3 The restrictions were identified according to the Cataloguing Methodology adopted by the work: Prof. Vera Comoli, Cultural and Environmental Assets in the Municipality of Turin, Politecnico di Torino, Department of Housing - Cities, Turin 1984.

Results: the 93 Historical Territorial Units in Turin

There are 93 HTUs identified from the territorial segments of the 40 Microzones of Turin that were defined as homogeneous areas from an urban-historical point of view across the municipal area; 14 of the small dimensional Microzones were not subdivided into HTUs since they were considered to be homogeneous considering the built-up plots from a physical-typological and historic point of view (Table 1a, b, c and Figure 1).

MICROZONE	HISTORICAL TERRITORIAL UNIT
01. Roma	-
02. Carlo Emanuele II	2.1 Po - Carlo Emanuele II
	2.2 Bodoni
	2.3 Carlo Felice
	2.4 Arsenale
03. Solferino	3.1 Solferino - Re Umberto
	3.2 Pietro Micca
04. Vinzaglio	-
05. Garibaldi	5.1 Garibaldi - Savoia - Palestro
	5.2 Statuto
	5.3 Orfane - XX Settembre
06. Castello	-
07. Vanchiglia	7.1 Po - San Maurizio
	7.2 Borgo Vanchiglia
	7.3 Vanchiglietta
	7.4 Regio Parco
	7.5 Borgata Rosa - Parco del Meisino
08. Rocca	-
09. Valentino	9.1 Vittorio Emanuele II - Valperga Caluso
	9.2 Valperga Caluso - Bramante
10. San Salvario	-
11. Dante	11.1 Marconi - Dante
	11.2 Arquata
	11.3 Dante - Bramante
12. San Secondo	12.1 Vittorio Emanuele - Stati Uniti
	12.2 Stati Uniti - Somellier
13. Stati Uniti	-
14. Galileo Ferraris	-
15. De Gasperi	15.1 Cassini - Spina Centrale
	15.2 Turati - Re Umberto
	15.3 Chisone
16. Duca d'Aosta	-
17. Spina 2	-
18. Duchessa Jolanda	18.1 Cit Turin
	18.2 Cibrario - Piffetti
19. San Donato	19.1 Regina Margherita - Umbria
	19.2 Cibrario - Regina Margherita
	19.3 Borgata Campidoglio
20. Porta Palazzo	20.1 Repubblica
	20.2 Borgo Dora

Table 1a The Historical Territorial Units of the Microzones of Turin - *Source: Authors'elaboration on TREMO data*

MICROZONE	HISTORICAL TERRITORIAL UNIT
21. Palermo	21.1 Cigna
	21.2 Aurora
	21.3 Borgata Monterosa
	21.4 Borgata Regio Parco - Sofia
22. Michelotti	22.1 Barriera di Casale
	22.2 Madonna del Pilone
23. Crimea	23.1 Borgo Po
	23.2 Fiume
24. Collina	24.1 Val Salice - Val San Martino - Reaglie
	24.2 Mongreno - Superga
	24.3 Cavoretto - Fioccardo
	24.4 San Vito
25. Zara	-
26. Carducci	26.1 Carducci - Giacomini
	26.2 Bengasi - Passo Buole
27. Unità D'Italia	-
28. Lingotto	28.1 Lingotto Fiere - Fiat Avio
	28.2 Sebastopoli - Galimberti
	28.3 Traiano - Onorato Vigliani
29. Santa Rita-Mirafiori	29.1 Traiano
	29.2 Orbassano - Santa Rita
	29.3 Zona olimpica
	29.4 Guido Reni
30. Mirafiori Sud	30.1 Unione Sovietica - Orbassano
	30.2 Città Giardino
	30.3 Drosso - Parco Colonnetti
	30.4 Borgata Mirafiori
31. San Paolo	31.1 Borgo San Paolo
	31.2 Cenisia
32. Pozzo Strada	32.1 Rivoli
	32.2 Monte Cucco - Bardonecchia
	32.3 Ruffini
33. Aeronautica/Parella	33.1 Borgata Parella
	33.2 Marche
	33.3 Risorgimento
	33.4 Chironi
	33.5 Campanella
34. Spina 3	-
35. Madonna di Campagna	35.1 Lucento
	35.2 Stampalia
	35.3 Borgata Madonna di Campagna
	35.4 Borgata Vittoria
36. Spina 4	-
37. Rebaudengo	37.1 Respighi
	37.2 Derna - Rebaudengo

Table 1b The Historical Territorial Units of the Microzones of Turin - *Source: Authors'elaboration on TREMO data*

MICROZONE	HISTORICAL TERRITORIAL UNIT
38. Corona Nord Ovest	38.1 Vallette
	38.2 Falchera
	38.3 Lanzo
	38.4 Taranto
	38.5 Stura
39. Spina 1	-
40. Barca Bertolla	40.1 Barca
	40.2 Bertolla

Table 1c The Historical Territorial Units of the Microzones of Turin (Source: Authors'elaboration on TREMO data)

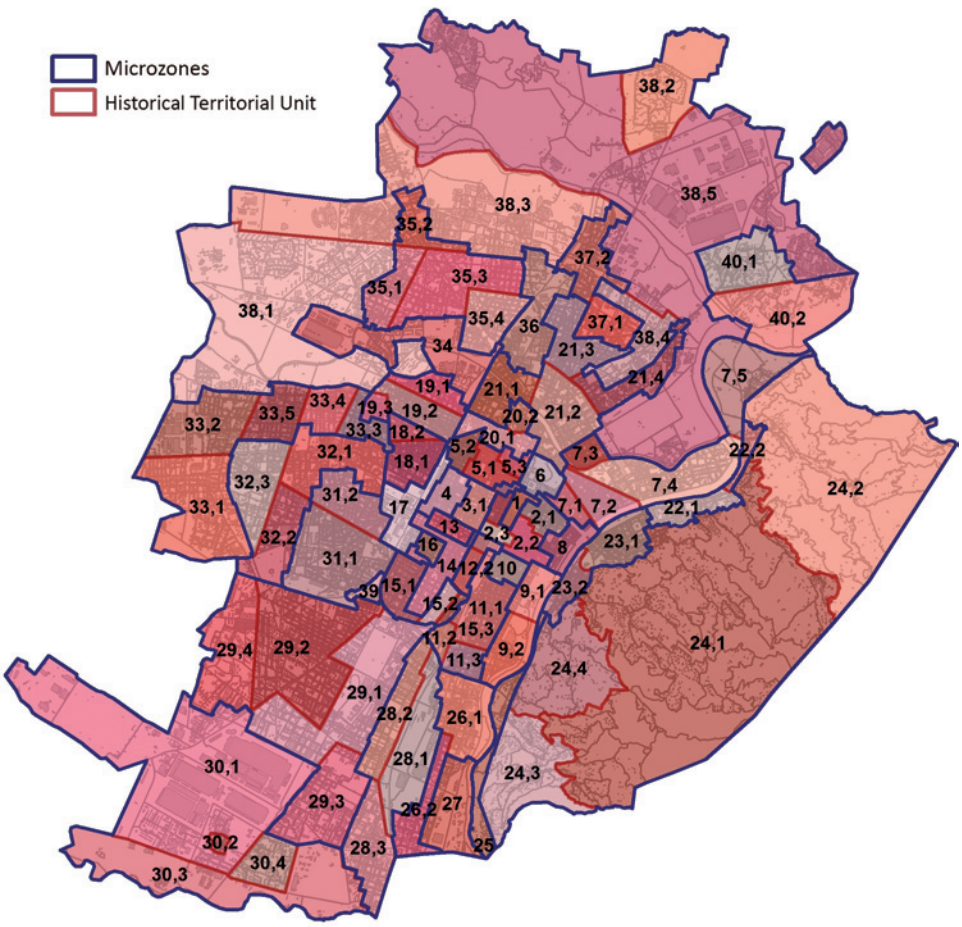


Figure 1 The boundaries of the 40 Microzones of Turin and the 93 Historical Territorial Units - *Source: Authors'elaboration on TREMO data*

PROPERTY PRICES IN THE HISTORICAL TERRITORIAL UNITS OF TURIN

Methodology

An empirical analysis was conducted using a traditional hedonic model to measure the influence of the spatial component on property prices. In particular, starting from the territorial segmentation of the Microzones in the HTUs, the explanatory power of the positional variables Microzones (first application) and HTUS (second application) were studied in the listing price determination process, by using a sample of housing units offered on the market in Turin in the four-year period between 2013-2016.

In addition to the positional variable, a number of explanatory variables were considered, in relation to the characteristics of the housing units and buildings, published on real estate advertisements and these were integrated with the layers of information from the Land Information System of the TREMO, according to the following formula:

$$Y = \alpha_k + \sum_{i=1}^{n} \alpha_i X_{ik} + \cdots + \sum_{i=1}^{n} \beta_i Z_{im} + \varepsilon \quad (1)$$

where Y is the logarithm of LP, measured in Euro per square metre, α_k is the model intercept, the explanatory variables X_{ik}, k = *1,... K* and Z_{im}, *m =1,...,M* are the dummy variables introduced for the characteristics Microzone or HTP and for any of the n characteristics related to the housing units and respective buildings, the hedonic weights α_i and β_i assigned to each dummy variable are equivalent to the contribution of the single characteristic level to the price value (Rosen, 1974) and ε the error term.

Sampling of data

The sample was made up of 1758 property listings in Turin published in 2013-2016 on real estate advertisements.

Given the known difficulty in using transaction prices in the Italian real estate market, listing prices were analysed, despite the limitations that these represent (Horowitz, 1992; Curto *et al.*, 2012). Nevertheless recent studies showed that the use of listing prices for studying the real estate market and estimating house values is viable. This is due to the fact that agents and sellers tend to correctly determine property prices and predict the influence of observable characteristics of buildings and apartments in the process of price determination (Curto *et al.*, 2015; Curto *et al.*, 2017b).

Clearly, in models that use listing prices, stochastic components carry more weight and therefore lower coefficients of determination are to be expected. The sample used for the analyses conducted in this study was extracted from an initial sample of 2238 housing units observed during the four-year period between 2013-2016 by the TREMO in order to observe property prices for the residential sector in the 40 Microzones. The annual follow-up process for the implementation of the TREMO data warehouse was to conduct a stratified sampling for each Microzone, followed by a verification of the statistical significance of the subsamples for each Microzone and by an in-depth analysis and possible elimination of outliers, in accordance with the criteria of the Quality Process of the TREMO.[4]

From the initial sample of property listings published in the four-year period 2013-2016, it was, therefore, not necessary to delete outliers. In order to make the sample more homogeneous, data on housing units located on the ground floor and on the top floors (attics) and in isolated buildings,

multi-family dwellings and on terraced properties (which usually have a limited number of above-ground floors) were deleted. This type of data cleaning responded to the need to reduce the high level of spread of residential units types and to accurately analyse the "Allocation floor" variable of the housing unit by means of the hedonic model. The Allocation floor variable usually affects the price determination process even if is often not revealed by the hedonic model applications. The final 1758 data samples could, however, provide a good territorial coverage over both the Microzones and the 93 HTUs (Figure 2 and Table 2).

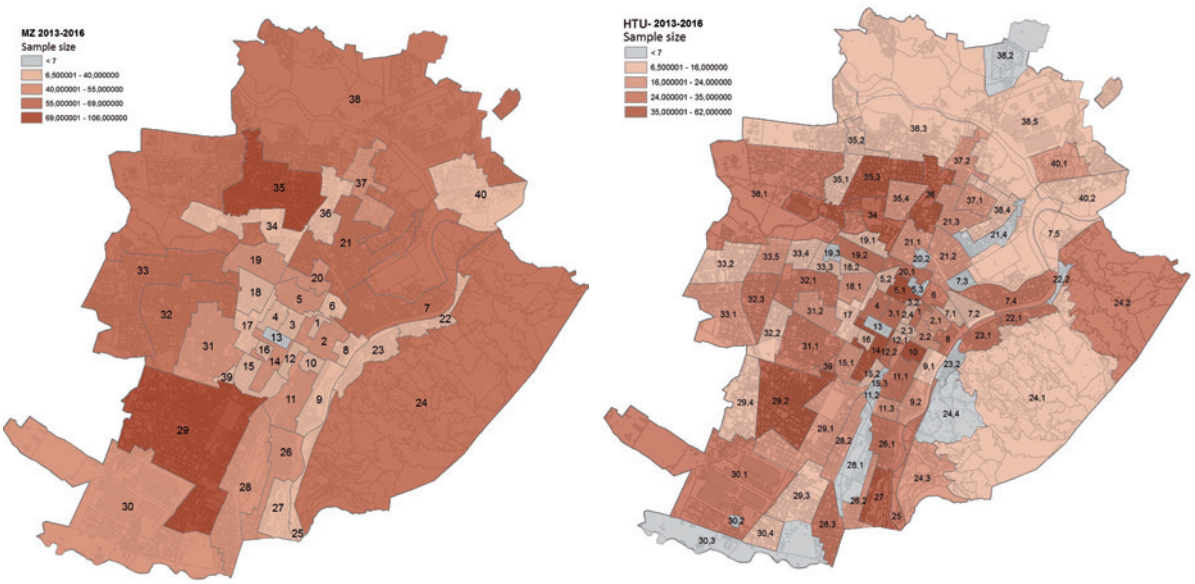


Figure 2 Samples' sizes for each Microzone (left) and for each HTU (right) - *Source: Authors'elaboration on TREMO data*

4 The main objective of the Quality Process of the Turin Real Estate Market Observatory (TREMO) is, the progressive improvement of the real estate market observation methodologies and the strengthening of the statistical data processing conducted on the databases of the TREMO. It includes robust data collection procedures and related sample surveys and statistical data processing finalized to check the due diligence and the significance of the data and the results of the methodological applications provided. In order to ensure the statistical significance of the data samples, for each Microzone, the territorial coverage is verified, the Error Profile is calculated, in addition to the basic descriptive statistics which already provide a good interpretation of the real estate market, with the aim of identifying possible sampling errors (outliers) and highlighting anomalous values with respect to the ordinary market. This second level of verification implies, for example, the calculation of confidence intervals (whenever necessary and possible per average data sample), box-plot, as well as the application of the preliminary tests for measuring the normality of the data distribution in each Microzone.

VARIABLE	LEVEL	FREQ.	LEVEL	FREQ.	LEVEL	FREQ.	LEVEL	FREQ.
Microzone	1	1.76%	11	3.13%	21	3.75%	31	2.90%
	2	3.07%	12	2.16%	22	2.05%	32	3.92%
	3	2.28%	13	0.28%	23	1.82%	33	3.92%
	4	1.82%	14	2.50%	24	3.36%	34	2.28%
	5	2.84%	15	2.16%	25	1.82%	35	4.84%
	6	1.65%	16	0.68%	26	3.01%	36	2.10%
	7	3.47%	17	0.57%	27	2.16%	37	2.73%
	8	1.65%	18	1.99%	28	2.96%	38	3.47%
	9	1.88%	19	2.67%	29	6.03%	39	1.54%
	10	2.05%	20	2.39%	30	2.62%	40	1.71%
HTU	1	1.65%	12_1	0.46%	24_1	0.91%	33_1	1.08%
	2_1	1.02%	12_2	1.71%	24_2	1.42%	33_2	0.74%
	2_2	1.08%	13	0.23%	24_3	1.14%	33_3	0.46%
	2_3	0.46%	14	2.50%	24_4	0.23%	33_4	0.57%
	2_4	0.63%	15_1	1.31%	25	1.48%	33_5	1.02%
	3_1	1.59%	15_2	0.51%	26_1	1.65%	34	2.22%
	3_2	0.74%	15_3	0.34%	26_2	1.37%	35_1	0.74%
	4	1.82%	16	0.68%	27	2.16%	35_2	0.74%
	5_1	2.16%	17	0.57%	28_1	0.06%	35_3	2.33%
	5_2	0.46%	18_1	1.14%	28_2	1.25%	35_4	1.08%
	5_3	0.23%	18_2	0.85%	28_3	1.65%	36	2.10%
	6	1.65%	19_1	0.74%	29_1	1.14%	37_1	1.37%
	7_1	0.40%	19_2	1.71%	29_2	3.53%	37_2	1.37%
	7_2	0.91%	19_3	0.23%	29_3	0.46%	38_1	1.59%
	7_3	0.06%	20_1	1.99%	29_4	0.91%	38_2	0.11%
	7_4	1.48%	20_2	0.34%	30_1	1.65%	38_3	0.91%
	7_5	0.63%	21_1	1.02%	30_2	0.06%	38_4	0.46%
	8	1.65%	21_2	1.19%	30_3	0.11%	38_5	0.40%
	9_1	0.63%	21_3	1.37%	30_4	0.80%	39	1.54%
	9_2	1.25%	21_4	0.23%	31_1	1.76%	40_1	1.02%
	10	2.05%	22_1	1.93%	31_2	1.14%	40_2	0.68%
	11_1	1.71%	22_2	0.11%	32_1	1.65%		
	11_2	0.11%	23_1	1.48%	32_2	0.80%		
	11_3	1.31%	23_2	0.34%	32_3	1.54%		

Table 2 Frequency of sample data for each Microzone and for each HTU
Source: Authors'elaboration on TREMO data

On the basis of the observed property listings, the characteristics related to both the housing units and their respective buildings were taken into consideration. These characteristics, included in the hedonic model were distinguished by: positional variables (Microzone, HTU), nominal scaled variables

(date of the property listing - year, apartment condition, building quality, building construction period) and combined variables (allocation floor with/without elevator) (Table 3).

HOUSING UNIT			BUILDING		
Variable	**Level**	**Freq. (%)**	**Variable**	**Level**	**Freq. (%)**
Date of the property listing (year)	2013	24.23%	Building quality	PregioClassy	9.39%
	2014	23.44%		Signorile	21.96%
	2015	27.82%		Medio	36.75%
	2016	24.52%		Economico	28.44%
Apartment condition	New/Refurbished	30.72%		Popolare	3.24%
	Not to be renovated	39.59%		NA	0.23%
	To be partially renovated	17.01%	Year of construction of the building	< 1918	14.79%
	To be completely renovated	12.57%		1919-1945	15.07%
	NA	0.11%		1946-1960	13.94%
Allocation floor with/without elevator	1st floor - no elevator	3.07%		1961-1970	17.80%
	1st floor – elevator	16.72%		1971-1980	7.39%
	2nd floor - no elevator	2.56%		1981-1990	1.08%
	2nd floor - elevator	16.72%		1991-2000	1.25%
	3rd floor - no elevator	2.33%		2001-2005	0.91%
	3rd floor - elevator	15.47%		> 2006	0.68%
	4th floor - no elevator	0.80%		NA	27.08%
	4th floor - elevator	13.65%	Building construction period	< 1946	29.86%
	5th floor - no elevator	0.40%		1946-1980	39.14%
	5th floor - elevator	8.59%		>1980	3.92%
	6th floor - no elevator	0.06%		NA	27.08%
	6th floor- elevator	3.47%			
	7th floor - elevator	3.19%			
	8th floor - elevator	1.76%			
	9th floor - elevator	0.91%			
	NA	10.30%			

Table 3 Frequency of sample data for each level of the considered variables (characteristics related to both the housing units and their respective buildings) - *Source: Authors'elaboration on TREMO data*

It is pointed out that the "building quality" variable was defined by 5 levels that were attributed on the basis of a set of typological characteristics defined and based on the study of the city's built-up area. The highest level corresponds to buildings characterized by a high architectural value, both historical and modern, whereas the lowest level represents buildings that were originally built as economical and council housing.

Furthermore, the variable "building construction period" was created by aggregating the levels of the "year of construction of the building" variable to around the periods corresponding to the main development phases of the city of Turin.[5] It is important to note that, like most Italian cities, the building heritage of Turin is represented by old buildings and buildings that were built after the Second World War.

An analysis of the unit prices of the sample revealed that several housing units had a price higher than the mean sample price (maximum outliers). These observations referred to housing units located in the city's most valuable Microzones and they followed the price trends of the relative Microzones. It was therefore decided not to eliminate them from the sample, in line with the sampling criteria adopted by the TREMO (stratified per Microzone) for the implementation of the database used for this analysis. The mean sample price is 2363 €/ m^2, with a standard deviation of 1051 €/m^2.

The territorial distribution of prices in the 40 Microzones and in the 93 HTUs (Figure 3) showed that the area with the largest mean prices extended from the city centre to the east on the hills, whereas the areas with lower prices were situated in the north and south areas of the city. In some cases it may be noted that the average prices attributed to the HTUs were not equally distributed within the relative Microzones, insofar as they were conditioned upon the physical limits (rivers, railways) and historical patterns of the city (the development of major roads, social housing districts). Microzones 5, 21, 33 and 38 are highlighted as an example.

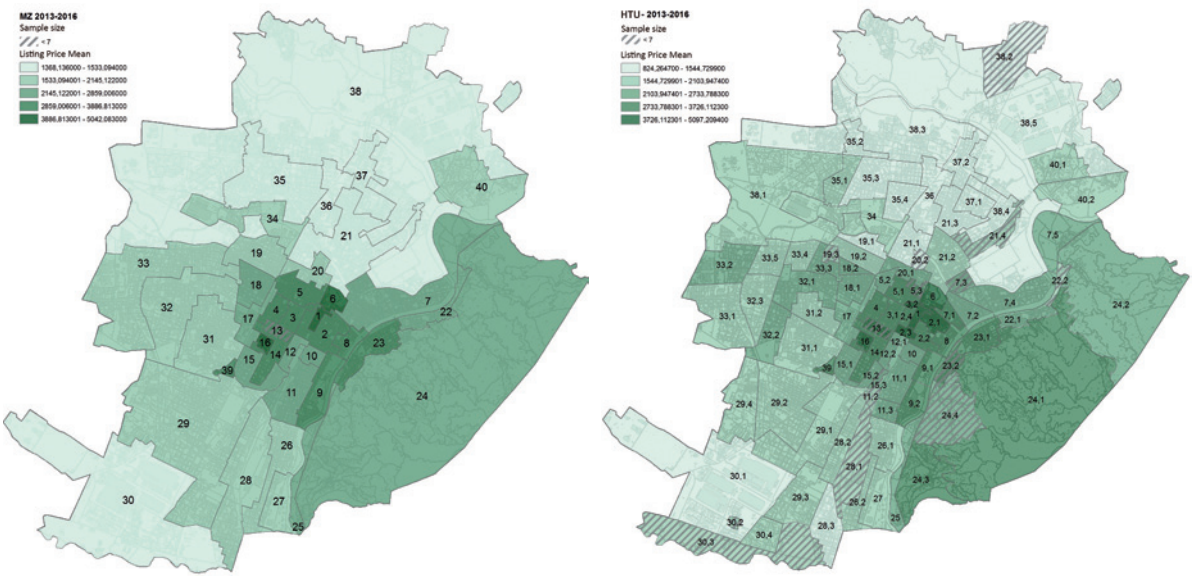


Figure 3 Territorial distribution of mean prices per square metre for each Microzone (left) and for each Historical Territorial Unit (right) - *Source: Authors'elaboration on TREMO data*

The Gini index was calculated for some of the variables considered in order to support the analysis of the variability of the frequency of sample data (Gini, 1912; Ceriani and Verme, 2012).

5 The construction of the variables "Building construction period" and "Year of construction of the building" was made possible by the LIS of the TREMO joined with the data warehouse of the Municipality of Turin containing, for each building of the city of Turin, a series of information including: Address, street number, decade in which the building was constructed, category of use.

Bearing in mind that this index may be included between 0 and 1, it showed that the sample data was heterogeneous with respect to the variables: “Building construction period,” “Building quality,” “Apartment condition” and “Date of the property listing (year)” (Table 4).

VARIABLE	IG	IGN
Building construction period	0.541394	0.812091
Building quality	0.724758	0.905948
Apartment condition	0.703503	0.938005
Date of the property listing (year)	0.74888	0.998507

Table 4 Gini indices for the variables: “Building construction period,” “Building quality,” “Apartment condition” and “Date of the property listing (year)” - *Source: Authors’elaboration on TREMO data*

Focusing on the “building construction period” variable, underlying the historical territorial segmentation of the Microzones, the building construction periods for each HTU are represented in Figure 4.

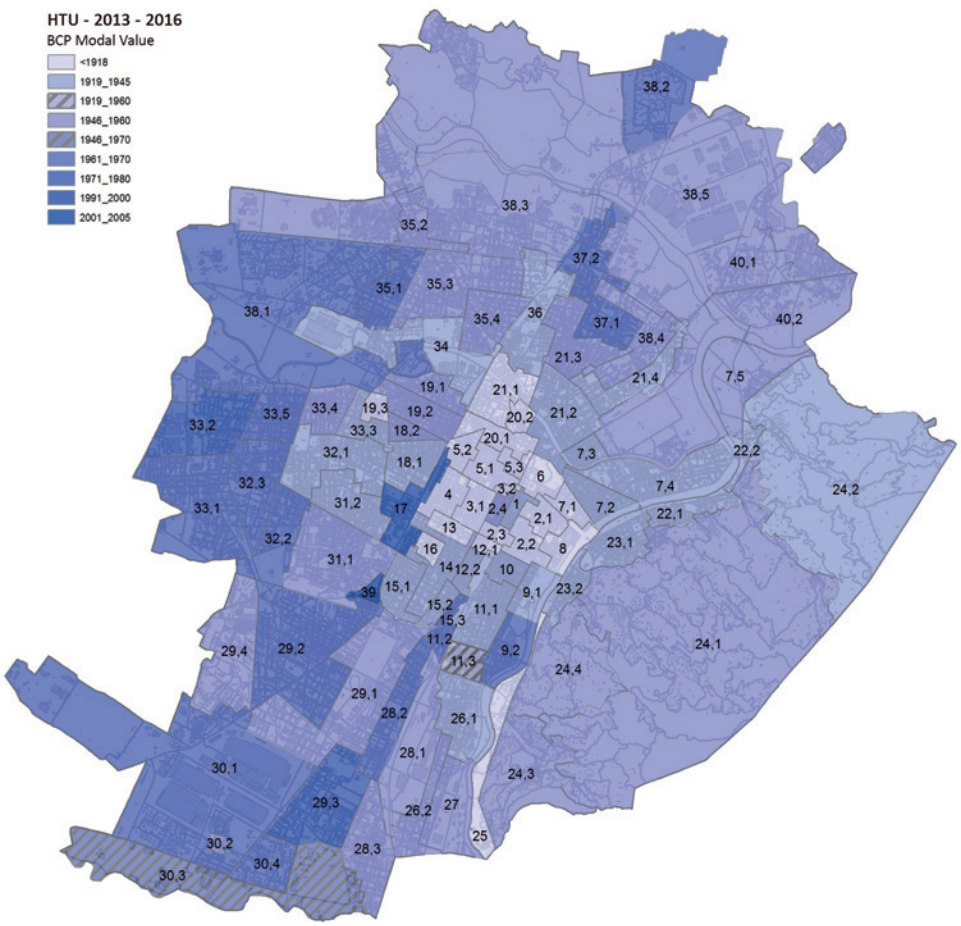


Figure 4 Modal value: “Building construction period (BCP)” for each HTU
Source: Authors’elaboration on TREMO data, provided by the Municipality of Turin on 21 December 2016.

Results

The influence of the spatial component on the property price determination process, represented by the "Microzone" and "Historical Territorial Unit" positional variables, was studied by applying a traditional hedonic model described in the "Methodology" section on the data sample previously illustrated.

Before applying the model, the normality of the dependent variable (logarithm of the listing price) was tested: the Shapiro-Wilk test did not reject the assumption of normality (with a p-value p >0.05) and the measure of the asymmetry of the probability distribution (skewness) was closed to zero. The Breush-Pagan test revealed the absence of heteroscedasticity in both models and the presence of multicollinearity was verified by means of the Variance Inflation Factors (VIF). The VIF was lower than 10, so that the presence of a problematic multicollinearity could be excluded. With regard to this, it is pointed out that the positional variable often generates multicollinearity; nevertheless, considering the aims of the present study and its descriptive (and not predictive) purposes, this result was considered acceptable. It can be also deduced that the positional variable can be considered as a proxy variable of other variables included in the model.

Therefore, the two models were applied, in which, in addition to the positional variable, the following explanatory variables were included:

- positional variables: Microzone or HTU;
- variables related to the characteristics of the housing units: date of the property listing (year), apartment condition, allocation floor with/without elevator;
- Variables related to the features of the buildings: building quality, building construction period.

It was decided to include in the model the variables which represented the characteristics of the housing units and buildings that proved to be the most significant in the price determination process. The selection of these variables is the result of a series of model applications considering different combinations of features. Among the variables considered and then excluded from the model are the following examples: number of façades, presence/absence of a concierge service, number of rooms, number of balconies/terraces, Energy Performance Certificate. The exclusion of the latter variable takes on a particular significance which distinguishes Italy from other countries, where the energy performance of buildings is valued by the real estate market and translated into marginal prices (Fregonara *et al.*, 2014; Fregonara *et al.*, 2017).
The results from the first application, where the "Microzone" assumed this positional feature according to formula (1), showed a determination coefficient (Adjusted R^2) equal to 0.80 (Table 5). The p-value of the model was close to zero, therefore the relationship between the dependent and independent variables was statistically significant (taking into account the level of significance as equal to or less than 0.05).

		UNIT LISTING PRICE (LOG) (Dependent Variable)			
Variable	**LEVELS**	**ESTIMATE**	**St. Error**	**Pr(>|t|)**	
(Intercept)		7.56	0.04	< 2e-16	***
Microzone	1	0.67	0.05	< 2e-16	***
	2	0.40	0.05	< 2e-16	***
	3	0.35	0.05	0.00	***
	4	0.30	0.05	0.00	***
	5	0.25	0.05	0.00	***
	6	0.46	0.05	< 2e-16	***
	7	0.03	0.05	0.49	
	8	0.39	0.05	0.00	***
	9	0.28	0.05	0.00	***
	10	0.09	0.05	0.09	.
	11	Omitted			
	12	0.10	0.05	0.06	.
	14	0.17	0.20	0.41	
	15	0.26	0.05	0.00	***
	16	0.11	0.05	0.03	*
	17	0.56	0.09	0.00	***
	18	0.00	0.12	0.98	
	19	0.16	0.05	0.00	**
	20	-0.13	0.05	0.01	**
	21	-0.48	0.04	< 2e-16	***
	22	0.14	0.06	0.01	**
	23	0.42	0.05	0.00	***
	24	0.21	0.06	0.00	***
	25	0.04	0.06	0.58	
	26	-0.21	0.05	0.00	***
	27	-0.13	0.05	0.01	*
	28	-0.21	0.05	0.00	***
	29	-0.17	0.04	0.00	***
	30	-0.29	0.05	0.00	***
	31	-0.17	0.05	0.00	***
	32	-0.12	0.04	0.01	**
	33	-0.16	0.04	0.00	***
	34	-0.31	0.07	0.00	***
	35	-0.45	0.04	< 2e-16	***
	36	-0.46	0.05	< 2e-16	***
	37	-0.48	0.05	< 2e-16	***
	38	-0.41	0.05	< 2e-16	***
	39	0.06	0.07	0.40	
	40	-0.27	0.07	0.00	***

		UNIT LISTING PRICE (LOG) (Dependent Variable)			
Variable	**LEVELS**	**ESTIMATE**	**St. Error**	**Pr(>|t|)**	
Date of the property listing (year)	2013	Omitted			
	2014	-0.09	0.02	0.00	***
	2015	-0.17	0.02	< 2e-16	***
	2016	-0.19	0.02	< 2e-16	***
Apartment condition	New/Refurbished	0.24	0.02	< 2e-16	***
	Not to be renovated	0.16	0.02	0.00	***
	To be partially renovated	0.06	0.02	0.00	**
	To be completely renovated	Omitted			
Allocation floor with/without elevator	1st floor - no elevator	0.01	0.04	0.72	
	1st floor - elevator	Omitted			
	2nd floor - no elevator	-0.07	0.04	0.08	.
	2nd floor- elevator	0.08	0.02	0.00	***
	3rd floor - no elevator	-0.01	0.04	0.73	
	3rd floor - elevator	0.06	0.02	0.00	**
	4th floor - no elevator	-0.19	0.06	0.00	**
	4th floor - elevator	0.06	0.02	0.00	**
	5th floor - no elevator	-0.33	0.08	0.00	***
	5th floor - elevator	0.04	0.02	0.08	.
	6th floor - no elevator	-0.18	0.20	0.36	
	6th floor - elevator	0.06	0.03	0.06	.
	7th floor - elevator	0.14	0.04	0.00	***
	8th floor - elevator	0.08	0.05	0.17	
	9th floor - elevator	0.22	0.06	0.00	***
Building quality	Classy	0.28	0.03	< 2e-16	***
	Distinguished	0.20	0.02	< 2e-16	***
	Medium-level	0.08	0.02	0.00	***
	Economical	Omitted			
	Council housing	-0.16	0.04	0.00	***
Building Construction	< 1946	-0.04	0.02	0.01	**
	1946-1980	Omitted			
	>1980	0.09	0.03	0.00	**
Adjusted R^2		**0.80**			
p-value		**<2.2e-16**			

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Table 5 Results derived from the first application of the hedonic model (positional variable: "Microzone"). The Microzones that submitted statistically non-significant sub-samples due to a low sample run length were omitted from this table -*Source: Authors'elaboration on TREMO data*

By analysing the results in Table 5 it is first of all possible to notice that almost all Microzones presented significant estimates; it should be noted that the positive coefficients highlighted the city's most valuable Microzones.[6]

Even the “time variable” that indicated the year in which the housing units were placed on the market was significant: moreover, the decreasing of coefficients from 2013 to 2016 correctly pointed out the negative economic downturn that characterised the Turin real estate market in recent years due to the economic and financial crisis in the sector, which recorded a decline in the average listing price for the entire city, equal to 15% in four years for the residential segments used (related to buildings not recently constructed).

The apartment condition proved to be one of the characteristics that most influences listing prices; in fact, regression results showed that for renovated houses there was a positive coefficient higher than that one related to houses to be completely renovated.

The “Allocation floor” variable also represents a very interesting feature to be analysed but whose influence on the price should be interpreted in relation to the presence/absence of an elevator. Therefore, it was decided to create a combined variable (“Allocation floor with/without elevator”) and to remove from the sample the housing units allocated to the ground and top floors.

As regards to the characteristics of the buildings, it emerged that value and luxury houses, as well as those most recently built, were confirmed to be the ones that were able to have a positive influence on the listing price of housing units.

The application of the second model, where the “HTU” was assumed as the territorial unit according to the formula (1), showed a determination coefficient (Adjusted R^2) equal to 0.81 (Table 6), similar to the results obtained from the first model. Again, in this case, the p-value of the model was close to zero, therefore the relationship between the dependent variable and the independent variables was statistically significant.

6 The location variable was included in the model as a nominal scaled variable; this choice is more preferable than the option of including the average price of each Microzone/HTU in the model or that of inserting the modal value of the construction period, always classified according to each Microzone/HTU.

		UNIT LISTING PRICE (LOG) (Dependent Variable)			
Variable	**LEVELS**	**ESTIMATE**	**St. Error**	**Pr(>|t|)**	
(Intercept)		7.542	0.091	< 2e-16	***
HTU	1	0.726	0.096	0.000	***
	2_1	0.520	0.100	0.000	***
	2_2	0.451	0.101	0.000	***
	2_3	0.509	0.114	0.000	***
	2_4	0.351	0.107	0.001	**
	3_1	0.419	0.096	0.000	***
	3_2	0.375	0.106	0.000	***
	4	0.354	0.095	0.000	***
	5_1	0.315	0.096	0.001	**
	5_2	0.264	0.113	0.019	*
	6	0.520	0.096	0.000	***
	7_1	0.333	0.141	0.018	*
	7_2	0.098	0.106	0.353	
	7_4	-0.004	0.097	0.966	
	7_5	0.062	0.117	0.600	
	8	0.435	0.095	0.000	***
	9_1	0.269	0.110	0.014	*
	9_2	0.347	0.098	0.000	***
	10	0.133	0.095	0.163	
	11_1	0.070	0.095	0.465	
	11_3	0.001	0.101	0.990	
	12_1	0.223	0.123	0.069	.
	12_2	0.117	0.096	0.222	
	14	0.306	0.091	0.001	***
	15_1	0.167	0.097	0.086	.
	15_2	0.154	0.107	0.153	
	16	0.623	0.118	0.000	***
	17	0.009	0.143	0.949	
	18_1	0.261	0.099	0.009	**
	18_2	0.117	0.102	0.252	
	19_1	-0.272	0.110	0.014	*
	19_2	-0.122	0.097	0.210	
	20_1	-0.073	0.095	0.444	
	21_1	-0.482	0.101	0.000	***
	21_2	-0.260	0.100	0.010	**
	21_3	-0.584	0.101	0.000	***
	22_1	0.182	0.097	0.060	.
	23_1	0.492	0.100	0.000	***
	24_1	0.389	0.117	0.001	***

		UNIT LISTING PRICE (LLG) (Dependent Variable)			
Variable	LEVELS	ESTIMATE	St. Error	Pr(>|t|)	
	24_2	0.065	0.117	0.581	
	24_3	0.218	0.114	0.055	.
	25	0.148	0.163	0.363	
	26_1	0.019	0.106	0.861	
	26_2	-0.089	0.097	0.362	
	27	-0.286	0.098	0.004	**
	28_2	-0.111	0.095	0.242	
	28_3	-0.057	0.212	0.789	
	29_1	-0.094	0.099	0.341	
	29_2	-0.323	0.102	0.002	**
	29_3	-0.200	0.102	0.050	.
	29_4	-0.103	0.091	0.258	
	30_1	-0.334	0.101	0.001	***
	30_4	-0.186	0.213	0.381	
	31_1	-0.236	0.106	0.026	*
	31_2	-0.156	0.096	0.104	
	32_1	-0.117	0.102	0.251	
	32_2	-0.028	0.095	0.766	
	32_3	-0.117	0.108	0.279	
	33_1	-0.184	0.097	0.058	.
	33_2	Omitted			
	33_3	0.072	0.129	0.577	
	33_4	-0.174	0.110	0.115	
	33_5	-0.187	0.102	0.068	.
	34	-0.267	0.111	0.016	*
	35_1	-0.454	0.118	0.000	***
	35_2	-0.436	0.104	0.000	***
	35_3	-0.429	0.095	0.000	***
	35_4	-0.484	0.110	0.000	***
	36	-0.450	0.094	0.000	***
	37_1	-0.363	0.104	0.000	***
	37_2	-0.508	0.097	0.000	***
	38_1	-0.352	0.100	0.000	***
	38_3	-0.403	0.215	0.062	.
	38_4	-0.378	0.106	0.000	***
	38_5	-0.486	0.118	0.000	***
	39	-0.489	0.130	0.000	***
	40_1	0.081	0.108	0.457	
	40_2	0.354	0.095	0.000	***

		UNIT LISTING PRICE (LOG) (Dependent Variable)			
Variable	**LEVELS**	**ESTIMATE**	**St. Error**	**Pr(>|t|)**	
Date of the property listing (year)	2013	Omitted			
	2014	-0.084	0.017	0.000	***
	2015	-0.156	0.017	< 2e-16	***
	2016	-0.181	0.017	< 2e-16	***
Apartment condition	New/Refurbished	0.241	0.020	< 2e-16	***
	Not to be renovated	0.162	0.019	< 2e-16	***
	To be partially renovated	0.068	0.022	0.002	**
	To be completely renovated	Omitted			
Allocation floor with/without elevator	1st Floor - no elevator	0.025	0.035	0.485	
	1st floor - elevator	Omitted			
	2nd floor - no elevator	-0.087	0.041	0.035	*
	2nd floor - elevator	0.069	0.019	0.000	***
	3rd floor - no elevator	0.000	0.040	0.994	
	3rd floor - elevator	0.054	0.020	0.006	**
	4th floor - no elevator	-0.152	0.058	0.009	**
	4th floor - elevator	0.055	0.020	0.006	**
	5th floor - no elevator	-0.357	0.082	0.000	***
	5th floor - elevator	0.050	0.025	0.044	*
	6th floor - no elevator	-0.173	0.196	0.378	
	6th floor - elevator	0.073	0.034	0.033	*
	7th floor - elevator	0.144	0.038	0.000	***
	8th floor - elevator	0.081	0.055	0.142	
	9th floor - elevator	0.235	0.057	0.000	***
Building quality	Classy	0.240	0.028	< 2e-16	***
	Distinguished	0.165	0.022	0.000	***
	Medium-level	0.060	0.017	0.000	***
	Economical	Omitted			
	Council housing	-0.158	0.038	0.000	***
Building Construction Period	< 1946	-0.058	0.017	0.001	***
	1946-1980	Omitted			
	>1980	0.110	0.031	0.000	***
Adjusted R^2		**0.81**			
p-value		**<2.2e-16**			

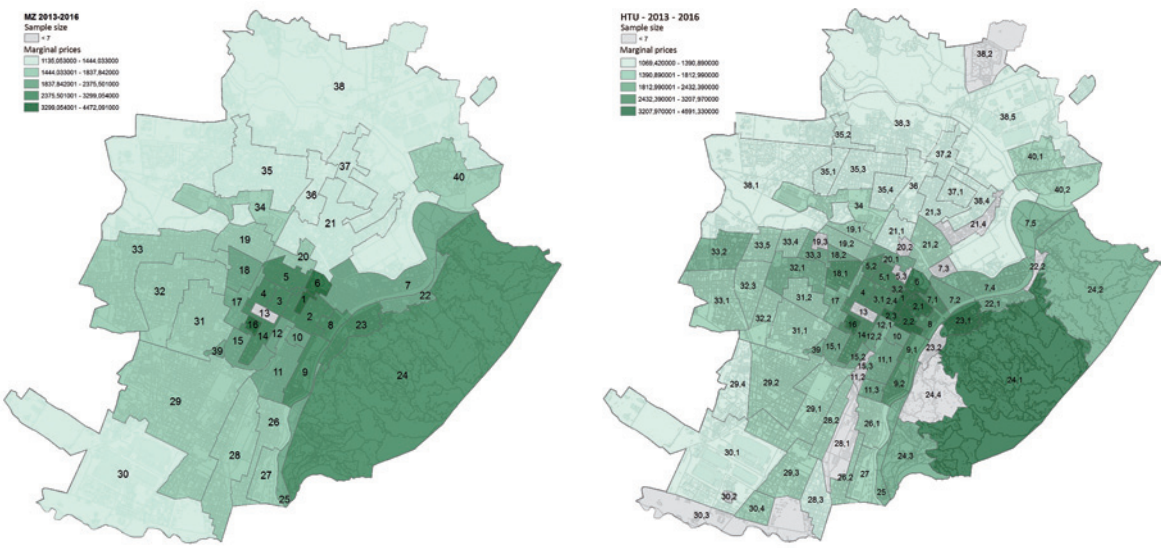
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Table 6 Results derived from the second application of the hedonic model (positional variable: "HTU"). The HTUs with statistically non-significant sub-samples due to a low sample run length were omitted from this table
Source: Authors'elaboration on TREMO data

Even when opting for HTUs instead of Microzones, the positional variable proved to be one of the most decisive features in price determination. The fact that all HTUs with a statistically robust data sample were very significant, equally to Microzones, pointed out that even territorial units smaller than the Microzones, although identified on the basis of a historical-urban analysis, are able to influence the property listing prices.

The study on the influence of the micro-neighbourhood – that somehow the HTUs represent - on prices requires further consideration and should be more thoroughly examined. More specifically it should be investigated whether and how other factors and physical features of the city (such as the presence of public green space, monuments, transports, services, etc.) can cause an increase or decrease in real estate values. To that effect, it is good to consider that the historical segmentation does not have unique consequences on the value systems, since within the same HTU there can be local hubs that are both positive for price increases (such as for example, a historical square) and negative (such as a railway station) (Barbaccia *et al.*, 2012).

Through a territorial analysis of the marginal prices as a result of the application of the two hedonic models, it was observed that the marginal price distribution, both with reference to the Microzones and the HTUs reflected the trend of the actual listing prices of the used sample; hence the model applied gave a good description of the variability of the contribution of the positional variable in price determination (Figure 5).



(**a**) (**b**)

Figure 5 Marginal prices derived from the two applications of the hedonic model: (a) First application (positional variable: Microzone); (b) second application (positional variable: HTU) - *Source: Authors'elaboration on TREMO data*

CONCLUSIONS

The influence of the positional variable in the determination process of property listing prices was investigated by analysing the case of the city of Turin and its territorial segmentation in Microzones and HTUs and applying two traditional hedonic models.

Both models' results were significant with a high coefficient of determination (Adjusted R^2) and a good explanatory power of the variables considered. In both models, the positional variable proved to be one of the most decisive features in the listing price determination process; this is made explicit through both the Microzone and the HTU.

It should be pointed out that the analysis outlined in this article did not pursue predictive objectives but rather it was carried out with a predominantly methodological and descriptive purpose. The influence of the micro-neighbourhood on prices may be further explored, more specifically through the study of whether and how other factors and elements that are also territorially defined - such as the exposure of a building on a garden or on a degraded area - can lead to an increase or decrease in real estate values. Nevertheless, it is possible to say that the HTUs represent significant territorial segments that may be used as points of departure for subsequent spatial analyses, for a possible review of the current Microzones and/or for identifying possible segments within these (buildings or spatial), in particular for larger Microzones, such as the Microzone n. 24 on the hills or the Microzone n. 38 which is extremely extensive and represents the northern part of the most peripheral areas of the city.

Future research may be directed to verify whether and which HTUs are homogeneous even in relation to property prices and therefore may further represent independent real estate submarkets. Furthermore, given that the Microzones have the same explanatory power of the HTUs, the possible aggregation of smaller Microzones could be also verified (Watkins, 2001; Whitehead, 1999).

References

Barbaccia I., Ghiraldo E., Festa M., (2012), Quotazioni immobiliari: effetti di vicinanza in mercati poco, dinamici, XXXIII conferenza italiana di scienze regionali, Territorio Italia, n. 2, pp.35-69.

Basu, S., & Thibodeau, T. G. (1998). Analysis of spatial Autocorrelation in House Prices, Journal of Real Estate Finance and Economics, 61-85.

Bates Lisa K. (2006), Does Neighborhood Really Matter?: Comparing Historically Defined Neighborhood Boundaries with Housing Submarkets, Journal of Planning Education and Research, 26; 5, DOI: 10.1177/0739456X05283254

Bor-Ming, H. (2012). Analisi della dipendenza spaziale dei prezzi delle abitazioni e dei sottomercati abitativi nella Tainan Metropolis, Taiwan, Territorio Italia, 11-24.

Bourassa S. C., Schneider E., Gale B. (2003), Housing Conditions and Challenges in Louisville's Western and Central Neighborhoods, Urban Studies Institute School of Urban and Public Affairs University of Louisville.

Bourassa S. C., Cantoni E., Hoesli M. (2007), Spatial Dependence, Housing Submarkets, and House Prices, Journal of Real Estate Finance and Economics, 35,143-160.9

Bourassa S. C. Cantoni, E Hoesli, M.(2010), Predicting house prices with spatial dependence: A comparison of alternative methods, Journal of Real Estate Research, Volume 32, Issue 2, 2010, Pages 139-159.

Ceriani L., Verme P. (2012), The origins of the Gini index: extracts from Variabilità e Mutabilità (1912) by Corrado Gini, The Journal of Economic Inequality, September 2012, Volume 10, Issue 3, pp 421–443.

Curto, R. (2005), Le Microzone della Città di Torino: ambito di conoscenza e di governance delle componenti territoriali e socio-economiche. In Analisi e modelli per la pianificazione teoria e pratica:lo stato dell'arte.

Curto R., Fregonara E. (2013), "Equità, catasto e governo del territorio. Una proposta metodologica a supporto della Pubblica Amministrazione ". In: Territorio Italia, vol. 2, pp. 29-44. - ISSN 2240-7707.

Curto R. Fregonara E., Semeraro P., (2015), Listing behaviour in the Italian real estate market, in International Journal of Housing Markets and Analysis, Vol. 8 Iss 1 pp. 97 – 117.

Curto R. A., Fregonara E. (2016), Analisi del patrimonio informativo sul mercato immobiliare di Torino (Italy) organizzato come Land Information System: rilevanza per le politiche territoriali e per il decision-making a scala urbana. In: Urban Data. Tecnologie e metodi per la città algoritmica / Roberto Pagani, Giacomo Chiesa. Franco Angeli, Milano, pp. 211-243. ISBN 9788891742049.

Curto, R. (1992). Qualità stratificate e mercato a Torino: un'applicazione dell'analisi di varianza, Genio Rurale, 53.

Curto R., Fregonara E., Semeraro P. (2012), Prezzi di offerta vs prezzi di mercato: un'analisi empirica. Asking Prices vs Market Prices: An Empirical Analysis., Territorio Italia, Roma, Agenzia del Territorio, Vol. XII, n.1, pp. 53-72.

Curto, R., Fregonara E., Semeraro P. (2017a), A spatial analysis for the real estate market applications. In: Advances in Automated Valuation Modeling. AVM After the Non-Agency Mortgage Crisis / D'Amato, Maurizio; Kauko, Tom. Springer International Publishing, pp. 163-179. ISBN 978-3-319-49746-4

Curto, R., Fregonara E., Semeraro P. (2017b), "Market Prices and Property Taxation in Italian Real Estate: A Turin Case Study." Appraisal: From Theory to Practice. Springer International Publishing, 2017. 141-155.

Fregonara E., Rolando D., Semeraro P. (2017), Energy Performance Certificates in the Turin real estate market, accepted for publication in Journal of European Real Estate Research (forthcoming).

Fregonara E.; Rolando D., Semeraro P., Vella M. (2014), The impact of Energy Performance Certificate level on house listing prices. First evidence from Italian real estate. In: AESTIMUM, vol. 65. - ISSN 1592-6117.

Gini C. (1912), Variabilità e Mutuabilità. Contributo allo Studio delle Distribuzioni e delle Relazioni Statistiche. C. Cuppini, Bologna (1912).

Goodman A. C., Thibodeau T. G. (1998), Housing Market Segmentation, Journal of Housing Economics, 7, pp. 121-143.

Goodman A. C., Thibodeau T. G. (2003), Housing market segmentation and hedonic prediction accuracy, Journal of Housing Economics 12, 181–201

Horowitz J. L. (1992), The Role Of The List Price In Housing Markets: Theory And An Econometric Model, Journal Of Applied Econometrics, 7, pp. 115-129.

Mackaness W. A., Ruas A., Sarjakoski L.T., 2007, Generalization of Geographic Information: Cartographic Modelling and Applications, W.A. eds. Elsevier.

Rosen S., (1974); Hedonic prices and explicit markets: production differentiation in pure competition, The Journal of Political Economy; Vol. 82 No. 1; pp. 34–55.

Semeraro, P., Fregonara E. (2013), "The impact of house characteristics on the bargaining outcome", Journal of European Real Estate Research 6.3: 262-278.

Slocum T.A., McMaster R.B., Kessler F.C., Howard H.H., Thematic Cartography and Geovisualization, third ed. Pearson Prentice Hall, 2009.

Watkins C. A (2001), The definition and identification of housing submarkets, Environment and Planning A 2001, volume 33, pages 2235- 2253, DOI:10.1068/a34162

Whitehead C.M.E. (1999), Chapter 40 Urban housing markets: Theory and policy, Handbook of Regional and Urban Economics, Volume 3, Pages 1559-1594.