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The value spatial component in the Real Estate Market: the Turin case study

In the study of variables affecting the determination of property prices, the spatial component is playing an increasingly significant role. In order to quantify the property value variability due to its location, it is necessary to resort to spatial statistics. The aim of this paper is twofold. On the one hand, we propose a geostatistical model aimed at identifying the incidence of position on housing asking prices. Starting from a geostatistical model we propose a methodology to empirically measure the incidence of a geographical segmentation on asking prices. The purpose of this paper is to test whether appraisers take account of the location in defining the asking prices, that represent the first signal of houses values. The proposed model is tested on a sample of residential properties, listed on the Turin real estate market. On the other hand, staring from the results of the model, the purpose of the present work is to formulate economic-estimative interpretations of the Turin real estate market dynamics.

Keywords: *spatial statistics, real estate market, submarkets*

Parole chiave: *statistica spaziale, mercato immobiliare, statistica territoriale*

JEL: *C21; R12; R15; R30; R31*

1. Introduction

Studies on the housing market currently occupy a central position within the context of economic issues[1]. Mainly due to the global financial crisis, the role played by the real estate market within the overall economic background is increasingly evident, and particularly the housing sector.

On the theoretical-methodological side, the aspects associated with the crisis accentuated the urgent need to revisit scientific research finalized to support analysis and knowledge of the real estate market dynamics. In fact, a great impulse has been given to a review process which already existed, at least to a certain extent, for reasons partly independent of the financial and economic crisis.

For several decades, a vast literature has expanded on market analysis and, in particular, on the study of the determinants of prices of residential properties, with both descriptive as well as predictive aims. Currently, a critical role has been ascribed to the spatial component which, in the form of "position", can influence the value systems of real estate assets. A study of the market cannot, therefore,

[1] The work was done and discussed collectively in all its parts. However, items 2, 4 and 5 were laid out by Elena Fregonara, point 4.1 by Diana Rolando, points 3, 3.1, 3.2, 3.2.1 by Patrizia Semeraro. Point 4.2 by Diana Rolando and Patrizia Semeraro. Introduction and conclusions were drawn up jointly by the three Authors.

ignore spatial components - framed naturally within a specific economic phase - whatever the scale of reference: the entire city, a portion of its territory, different portions of territory subject to comparison.

It is here that spatial statistics bears fruit, and the arguments presented here are located directly within them.

The development of spatial analysis is based on and follows past experience, the roots of which lie in multivariate statistics and econometrics. In these studies, the central focus of argument is the real estate asset with its own characteristics, alongside the variables normally considered in relation to the prices of dwellings: inflation, the trend of the yield curve, bank lending policies, the national mortgage markets, etc. An example is the extensive scientific research on hedonic pricing, which, for some time, has tested methods and models to estimate the marginal prices associated with qualitative and quantitative characteristics, which are key determinants in the formation of prices. Since the inception of the research, attention has focused on the heterogeneity of real estate assets, in relation to their physical structure and to economic factors specific to the markets in which they are present. The well-known essays by Rosen (Rosen, 1974), which represent a sort of milestone for scientific output in the sector, were followed by considerable current affairs press coverage. This represents the outcome of two fields of study. The first aims at the refinement of the procedures, resolving in general specific problems associated with the limitations of the traditional hedonic model (see for example Griliches, 1971; Palmquist, 1991). The second, thanks also to the contribution of technology particularly aimed at the construction of territorial information systems or real spatial data infrastructures, focuses on the testing of models capable of handling the spatial characteristics of real estate assets.

With regard to the second, in the more recent literature attention has shifted away from dealing with the characteristics relevant to price formation to dealing with one specific item: the "spatial fixity" of real estate assets. The centre of the argument is the role of location in determining the spatial distribution of prices, given a particular point in time. It is recognized that the spatial fixity of assets, together with the diversification of values by territorial area and the effects on price systems of temporal variation, is a factor capable of affecting the dynamics of the prices themselves. At the same time, it can be considered as a determining factor on the dynamics of sales, and therefore as determining consumer choice behaviour.

The inter-temporal component, the spatial fixity of properties and the heterogeneity of the real estate assets - all of which are now recognized as fundamental in the purchasing behaviour of consumers and in the investment decisions of construction enterprises - have a strong impact on the consolidated apparatus of analysis: one is dealing here with aspects which are in stark contrast to the neo-classic literature which presupposes a context of static, fixed-period analysis. Therefore, in this paper we will attempt to discuss those factors that affect the differentiation of prices at a given time. In particular, we seek to identify the incidence of location on the formation of the housing price.

The appraisal problem, from which the analysis to be developed in this paper originates, involves determining the value of the area only by means of the asking prices of dwelling units located there, in other words identifying the impact that location has on the price through the recorded prices alone.

Asking prices are the first signal of property values and in the International literature it is recognized (see e.g. Knight *et al.* (1998)) that considering them improves prediction accuracy. Moreover they leads market prices. In this paper we are going to analyze asking prices to empirically evaluate whether appraisers consider the location effect on prices in establishing houses values. Moreover since Bourassa analysis supports that the segmentation in geographical submarkets used by appraisers improve prediction accuracy as well as the more advanced spatial statistics models, our purpose is to support the thesis that the cadastral Microzones are used by appraisers to improve prediction accuracy.

Whit this aim, we propose a model to measure the incidence of the position on price variability. Moreover, we test it on the basis of a case study. Instead of considering the specific location, according to the recent papers of Bourassa (2010) that concludes that geographical submarket are fundamental to improve prediction accuracy, we consider the geographical segmentation through which several Italian cities are divided: the homogeneous Microzones. The case study to be presented – in relation to Turin – will show that the proposed methodology is able to capture the spatial variability of prices caused by variation of Microzone.

In the background, we incorporate the results of recent studies based on similar assumptions, for various purposes, for example (see Bourassa *et al.*, 2010 and references included): the identification of price indices associated with different areas of spatial aggregation and calculated according to the characteristics of real estate assets; the identification of the implicit marginal prices and their effects on price formation and consumer choice behaviour; support of town planning and housing policies and territorial government policy by improving knowledge of how the residential market functions. Within the ambit of this work, the focus of attention is on the spatial distribution of prices: the repercussions thereof will be considered on the orientation of economic policies at the urban level.

Section 2 discusses some theoretical and methodological premises, traceable to the main lines of research aimed at examining the spatial component of the value of properties. In Section 3 we are going to propose a methodology, based on the representation of prices as a spatial process according to geostatistical models, to quantify the value variability due to position, in order to be able to estimate the incidence of position on a residential unit of value. Section 4 discusses the city of Turin as a case study for testing the proposed model. Turin property values in fact reflect a precise geographical factor: the territory of the city segmented into 40 homogeneous Microzones. In particular, the sample used for the application is described and the data analysis performed. Finally, in Section 5 the results are discussed and interpreted, and a number of arguments of an economic-estimative nature are presented, representing a useful basis for future research.

2. Theoretical and methodological premises

Of particular interest for this study is the line of scientific research that focuses on the spatial fixity of real estate. In particular, the research line which explores the impact of variables (features) that depends on the geographic location of the property. The spatial dimension, in terms of fixity, as has been said, is a key determinant in the formation of prices.

At the theoretical level we propose a methodology to measure the incidence of location on housing prices.

Although we empirically analyse the asking prices to evaluate if the appraisers take into account of the marginal effect of location on prices, the incidence could be also computed on transaction prices. We recall hereafter the traditional hedonic models and the introduction of the location effect on housing prices.

A complete review of the literature concerning hedonic models can be found in Stanca (2008). The location marginal effect on housing prices is mainly due to the two following issues:

1. neighbourhood effects, or the characteristics of the area where the real estate asset is located. These, in the jargon of hedonic pricing models, are recognized as *micro-environmental characteristics* since they are associated also with qualitative aspects relating to environment or landscape of the micro-surrounding, with existing (or planned) infrastructural facilities, with demographic and socio-economic structures and with the quality of services. It is important to note that neighbourhood effects refer to territorially defined portions, such as, for example, the homogeneous Microzones of a city; therefore, the study focuses on the explanatory (or predictive) functions of the pricing. In contrast, the study of price variations based on neighbourhood effects may allow the identification, endogenously, of the relevant submarkets;
2. adjacency effects, due to the geographical location of the dwelling. Among these, the widely treated distance from the centre of the city, from hubs or nodes of particular importance or from areas without amenities. This second type of effect is closely related to geographic location and is relevant to the methodologies that privilege study of the spatial dimension as a key determinant in the formation of the price of dwellings.

Knight *at al.* (1998) assert that "submarket listing prices lead selling prices in the same submarkets. Moreover, listing prices taken from the market as a whole lead selling prices in many of the submarkets. This suggest that the predictive usefulness of listing prices may not be limited to traditional point-in-time, point-in-space appraisals, but rather may extend to the increasingly prevalent data-based appraisals".

In terms of theory, these and other elements inferable from the classical literature confirm that the analysis of price dynamics has long been linked to the analysis of spatial effects: to a point, today, where we are approaching the most advanced concept of *spatial structure of the data* (Longley *et al.*, 2001; Murgante, 2008).

At the methodological level, we find confirmation from the instrumental apparatus developed to deal with the spatial component of prices (Bourassa *et al*, 2010). For example, an empirical solution is proposed based on the hedonic price function, whose classic functional form may be supplemented by the neighbourhood effects component, resulting in application of the established Ordinary Least Squares (OLS) method. In general, we may recall, the functional form for hedonic price functions, on the assumption of linearity and spatial homogeneity of the parameters, is: $P = X\beta + \varepsilon$ (where P is the price of the dwellings and X the characteristics of the properties). If this is added to neighbourhood effects in the form of neighbourhood characteristics (N), we have: $P = N + X\beta_1 + \beta_2 + \varepsilon$, where β_1 and β_2 are the regression coefficients and ε is the error term.

However, this method reveals limits and errors of estimation. These are generally due to a number of key reasons, including: the incorrect identification or measurement of the characteristics, the action of the component of spatial heterogeneity of coefficients, spatial correlation in errors (which inhibits inference).

Limits and causes have been the subject of numerous studies, generally referable to three different approaches that are based:

1. on the modelling of spatial dependence through the use of indicators of geographic location;
2. on the modelling of spatial heterogeneity, thus presupposing that the hypothesis of constancy of the coefficients is not assumed;
3. on the construction of ad hoc models to describe the spatial dependence of the dependent variable or in the error term.

In the first case (tested on portions of territory defined as the homogeneous Microzones) the effect of the geographical features (expressed in terms of location, or accessibility) is internalized in the second equation above, in additive form. In this case, a correct identification of the indicators of geographic location is fundamental. In general, hedonic models test geographical indicators, which are explicit (e.g. distance from the centre), implicit (sets of dummy variables), geographic coordinates. Or, alternatively, the effect of the geographical component is modelled using regression coefficients identified by sets of *geographical* dummy variables.

In the second case, it is assumed that the contribution of the characteristics of dwellings varies according to geographical location. The focus is placed on the identification of submarkets. The use of models capable of including spatial heterogeneity is proposed as an alternative method, formalizing the relationship between marginal prices of characteristics of properties and spatial characteristics: for example, the *spatial expansion method* is identified in the literature. Or, for greater simplicity, a model is identified based on the variation of structural characteristics as a function of the characteristics of the neighbourhood, subject to the identification of appropriate indicators of the quality of the neighbourhood.

The third case, which is based on the construction of ad hoc models to describe the spatial dependence of the dependent variable or of the error term, is based on the use of spatial econometrics techniques. Among these, the spatial autoregressive models for the analysis of cross-sectional samples are well-known. These models, in some aspects similar to techniques for the analysis of time series, demonstrated a better predictive and explanatory ability than the traditional hedonic models (resolved with OLS) applied to property markets. Recent advances in autoregressive modelling, on the one side, are approaching the temporal component side by side with the spatial component, and on the other side, they are moving towards the testing of semi-parametric approaches used to describe of spatial variations in prices and to analyse error components (these too spatially related).

Obviously, the potential of this class of methods is enhanced by the possibility of using GIS (Anselin, 1998, Burrough 1986; Burrogh and McDonnell 1998); these, if conceived according to the broadest meaning of Land Information Systems (LIS), can in fact support – at the identification phases – data samples stratified and correlated to specific geographical areas, more or less circumscribed and more or less numerous depending on the objective of the analysis (appraisal or mass appraisal). Having a wealth of data organized in geo-related databases in the form of Geographic Information System (GIS) or, better, of Spatial Data Infrastructures - a variety of analysis are possible. For example, the knowledge of the city and its transformations, the study of the dynamics of the market and its value systems, also in relation to socio-economic changes (Curto and Fregonara, 2002). The development is also possible of methodologies finalized to study the price formation processes, the data concerning the market dynamics, or the houses changing and the related segments of demand.

Of course, the spatial component of the data and the possibility of geo-relating are – beforehand – the discriminator in the choice between multivariate statistical methods or geo-statistical methods. The latter allow a variety of possibilities in studying, for example, the improvement effects induced by urban policies, or the spontaneous processes in terms of property values; the analysis of the property values of dwellings influenced by the economic background as well as by economic trends; the handling of the phenomena of spatial autocorrelation in unitary sale prices, recorded during homogeneous time periods.

Moreover, they allow the creation of statistical studies of the survey-sampling variety with different aims (Curto *et al.*, 2010): for example, the identification of the reasons at the basis of the houses changing, the definition of significant profiles that could represent categories of people, the collection of opinions and judgements on reasons at the basis of particular choices or on the degree of satisfaction with specific housing situations, etc.

A general classification of methods of spatial statistics has been proposed on the basis of these premises, distinguishing between (Curto et al, 2010) traditional models based on parametric techniques and recent models, attributable to non-parametric methods. Among the latter it is possible to find the local regression models for analysis of geographic data (for predictive purposes), such as the well-known Geographically Weighted Regression (Fotheringham et al., 2002). GWR is a semi-parametric regressive method whose functional form is characterized by very few assumptions about the function f to be estimated and the probability distribution of errors. Compared with the classic linear regression model (note: $y = b_0 + b_1x_1 + e$), the geographical regression model, starting from the assumption of availability of the coordinates (u, v) of a given datum positioned in the area under investigation, can be expressed in the form $y(u,v) = b_0(u,v) + b_1(u,v)x_1 + e(u,v)$, where $b_0(u,v)$, $b_1(u,v)$ and $e(u,v)$ are respectively the local coefficients and the local error term. The resulting model allows a more robust estimate of the variables. The method allows to estimate not a single parameter, but a parametric function. More simply, the GWR makes it possible to estimate the progress of the parameter related to a characteristic, for example throughout the City of Turin, highlighting the differences in value between the different areas of the city.

A feature common to the methods cited above is the introduction, upstream, of homogeneous geographical areas through, for instance, the use of clustering algorithms (cluster analysis). Another important step, still preliminary, is the management of spatial autocorrelation through the grouping of buildings that are geographically close and show strong economic and typological homogeneity, taking account of the fact that the operation of the spatial effect on the formation of property values through zoning of the territory must be applied only if the groups are genuinely non-homogeneous between them.

The foregoing represents a component of the theoretical and methodological debate which can be more closely examined in the literature. Given our premises, a model is suggested which, allowing one to identify the spatial component of the price and to estimate it, enables one to confirm the significance of location in the formation of houses prices and, therefore, the opportunities provided by geo-statistical models.

3. The model

In light of the methodological assumptions made, it is clearly necessary to model the spatial component of the price. The model to be introduced in the next section belongs to spatial statistics, whose application to real estate is expanding in the literature – see works such as Pace *et al.* (1998), Bourassa *et al.* (2010), Dubin (1992), Dubin (1998), Peace and Gilley (1997), in that it allows the impact of spatial heterogeneity on price to be estimated.

Insofar as the model permits to quantify the incidence of location, the following sections will also deal with the consequences, from an estimating point of view, in determining the value of building lands, solely on the basis of the asking prices of residential properties. In particular, this aspect will be dealt with through a case study – the real estate market in the city of Turin – which will open the way to develop an empirical methodology. The case study will show, above all, that the model facilitates the description of some aspects of the functioning of the Turin market, and the confirmation of the strong link between prices and homogeneous Microzones.

3.1 The spatial component of value

In this section we introduce and develop the mathematical model used to identify the leverage of location in the formation of the market price of a property. The relation between the market value of a property and that of the development area to which the property belongs is:

$$W=I\,P, \tag{1}$$

where W is the value of the area, P the market price of the unit examined and I represents the incidence: obviously I belongs to the interval [0, 1] and is expressed in percentage terms. The methodology developed allows one to identify the incidence of the area through the variability of prices of properties belonging to a pre-established area A, for example identified by an urban zone. It follows from equation (1):

$$V[W]= I^2\,V[P], \tag{2}$$

the relation between price variability and the variability of the value of the area. The idea which lies at the basis of the model to be introduced is to represent the variability of the area through that part of the price variability caused by the change of location. In short, the territory is subdivided into small portions which allow the value of the area to be assumed as a constant in each portion. The variability of the local mean prices will be due mainly to the change of location. We now introduce these concepts more formally. In practise we start from a spatial model to perform an analysis of spatial price variation that is amenable to a one way analysis of variance (ANOVA).

Let us consider a classical spatial model: the price of a dwelling is represented by a spatial process defined on a geographical area A, represented as a subset of $\boldsymbol{R}^2$. The price of a dwelling randomly chosen in A depends on its location. Let us define a local price as a family of random variables parametrized by the position $\mathbf{z}$, $\{P(\mathbf{z})\!:\!\mathbf{z}\in A\}$, where P($\mathbf{z}$) is the price of a house in the position z in A. Therefore the observed data are the realization of a random process parametrized by the location that set this model in the contest of geostatistical ones (see for example Bourassa *et al.*, 2010). We do not make assumption on the model parameters, for any $\mathbf{z}\in A$.

Let now P be the random variable representing the price of a dwelling randomly chosen and belonging to A. We aim to relate it with the local prices P($\mathbf{z}$). To do that we have to consider the possible position $\mathbf{z}\in A$. Let us introduce a random variable Z representing the position of a unit randomly chosen from the area A. Since the building density is not homogeneous and depends on the urban area, it would be restrictive to assume that the distribution of Z is the uniform distribution on A. Roughly speaking the probability to sample a dwelling to two different zone included in the are A is different and depends on the two zones building density. The underlining idea consists it decomposing the price variation into two parts: the first one is the variation between dwellings in the same position (for example belonging to the same building), the second one is the variation entirely due to the change of position. However, a continuous model it is not suitable for the real estate market. In fact the number of buildings belonging to any given area is finite. The sample data are collected observing prices on the supply market: we associate to each dwelling its sampled position. Therefore, if we consider a small urban area it is possible that we don't have any observation. For this reason, to be able to extract a significative sample from a zone, it dimensions can not be negligible.

We therefore adopt a discrete version of the above model and develop the variation decomposition for the discrete model, resorting to a classical formula that will lead to a variance analysis amenable to the ANOVA.

The above premise lie at the basis of the following procedure. To do that we consider a finite partition of the area A, say $\{A_1,...,A_N\}$, such that *it is possible to assume that each area is spatially homogeneous, and therefore the component of price variability due to position is approximately zero on each element of the partition*. A consequence of the previous assumption is that the area value is assumed to be constant on each A_i, i=1,...,N. Under this assumptions, we define the discrete position variable Z as follows: Z=i if the randomly chosen dwelling belongs to $A_{i.}$ Let now p_i=P(Z=i), i=1,…n be the discrete density of Z.

Let P_i be the random price of a flat in A_i, i.e. P_i is the random variable whose distribution in the conditional distribution of the random price P given that the selected dwelling belong to the area A_i.

The estimation of the spatial component of prices variability is based on the following well variance decomposition formula, (see for example Ross, 2004), that we apply to the pair (P ,Z) representing the sampled dwelling price and the position.

Let us consider the random variables P and Z, we get:

$$E[P]=E[E[P|Z]]$$
$$V[P]=E[V[P|\ Z]]+V[E[P|\ Z]]. \qquad (3)$$

By means of (3) it is possible to split the variability of the random price P it into two components:

- the first one ($E[Var[P|Z]]$) is the mean of the local variances σ_z each of one is not due to the spatial variability, since the position is fixed;
- the second component, $V[E[P|Z]]$, is the variability of the local mean values $\mu_{z,}$ this component is entirely due to the spatial variability, since the local means do not take in account of the randomness in price for different units in the same position (for example different apartments belonging to the same building). We name this component, V[E[P|Z]], the *spatial component of Prices variance*, *SCPV.*

In order to estimate the spatial component of price we aim to evaluate the variability of local means. Therefore we use the component V[E[P|Z]] as a proxy for the area value variability, i.e. V[W] in equation (2). This is possible because the function h(Z)= V[E[P| Z]] represents the variability as a function of the position Z.

The assumption that the area value is constant on each set A_i is necessary in order to be able to consider the SCPV as a proxy for V[W].

Once defined the *SCPV* we *define the spatial incidence on price volatility*, as follows:

$$I^2=V(E[P|Z])/V(P). \tag{4}$$

Before discussing the estimating procedure performed, we recall and underline that V(E[P|Z]) is a good proxy for V[W] if W is constant, on each A_i. On the other side if the sets A_i are not homogeneous enough for the previous assumption the SCPV should be considered in a wide sense, as concerns the case study presented. In fact the zones A_i selected represents sub market, the area incidence on price is therefore a valuation of the percentage of a dwelling price due to the belonging to a given sub market.

3.2 The estimation procedure

This section is devoted to discuss the estimate of the model parameters. Let now consider the prices mean and standard deviation: $E[P]=\mu$, $\sigma=\sqrt{V(P)}$, $E[P_i]=\mu_i$ and $\sigma_i=\sqrt{V(P_i)}$.

Equations (3) become:

$$\mu = \Sigma_i p_i \mu_i.$$

$$\sigma^2 = \Sigma_i p_i \sigma^2_i + \Sigma_i p_i(\mu_i-\mu)^2. \tag{5}$$

By means of equations (3) and (5) it holds $V(E[P|Z])=\Sigma_i p_i(\mu_i-\mu)^2$, therefore $\Sigma_i p_i(\mu_i-\mu)^2$ is the *spatial component of Prices variance, SCPV.* The parameter to be estimated is the variance of the conditional means, i.e. the *SCPV.*

The *SCPV* can be obtained from (3) as the difference V[E(P|Z)]=V(P)-E[V(P|Z)]. The parameter E[Var(P|Z)] depends on the conditional variances Var(P|Z) and on the probabilities p_i. Let therefore S^2_i be the conditional sample variance, roughly speaking it is the sample variance of the price of a dwelling belonging to the area A_i and let $\bar{X}_i$ be the conditional sample mean, i.e. the sample mean of the price of a dwelling belonging to A_i. It only remains to be defined an estimator for the probabilities p_i.

In order to estimate the weights p_i the simplest way is to use the relative frequencies, i.e. the estimate q_i of p_i is:

$$q_i=n_i/n \tag{6}$$

where n is the sample size and n_i is the number of outcome belonging to the area A_i.

We now are able to introduce the estimator for E[Var(P|Z)]:

$S^2_S = \Sigma_{i=1}{}^N q_i \, S^2_i,$

Therefore the estimator for the *SCPV* is:

$S^2_{SCPV} = S^2 - S^2_S$

where S^2 is the sample variance of P. The above equation provide the variation decomposition amenable to a one way ANOVA. In fact the ANOVA is based on the decomposition of the total variation in a component within groups and a component between groups, see for example Navidi (2006).

The sample incidence I finally is:

$I = S^2_{SPVC} / S^2.$

As a first application it was decided to use the model for descriptive purposes and not for determining the value of building land. The next section is devoted to presenting the case study: the market of the city of Turin.

4. Case study: Turin Real Estate Market

The homogeneous Microzones of the city of Turin, Northern Italy, are the result first of the experience gained in identifying a methodology for their definition and, subsequently, in defining their boundaries (Fig. 1). Both phases were conducted in accordance with the provisions of Presidential Decree 138/1998 and subsequent Regulation of the Ministry of Finance. From the beginning we have been supported by a Geographic Information System, structured to be easily integrated with the databases finalized to monitor the real estate market and the construction activity in the city of Turin. The wealth of information, constantly updated, formed the basis for the activation in 2000 of the Real Estate Observatory of the City of Turin, after a test start-up phase. The Real Estate Observatory of the City of Turin exists thanks to the collaboration, formalized in specific research agreements and contracts between institutional entities: the City of Turin, the Chamber of Commerce of Turin and the Polytechnic of Turin (Scientific Manager, Professor Rocco Curto).

The cartographic and alphanumeric databases of the Observatory, each fed by its own particular sources, are updated continuously so as to constitute time series that are as complete as possible. This is to facilitate the conduct of analyses and to test out models with various purposes.

For example, data on the number of transactions for the whole city or its territorial portions (Microzones or clusters of Microzones) facilitates the analysis of market dynamics. By having to hand the asking prices for segments of the Residential–Used/Residential–New/Completely renovated property market as well as the actual sale prices, one can monitor the values on the basis of territorial reference. Since the characteristics of the properties are recorded in the databases, it is

Figure 1. The 40 Microzones of the city of Turin, Italy.

Source: Real Estate Observatory of the City of Turin.

possible to relate them to the values of the assets exchanged, sought and offered. And it is possible to relate the socio-economic data of demand, the structure and composition of supply, the population and the economic activities of the city. Simultaneously, private construction activity can be monitored in relation to public projects and interventions that are planned or underway.

Great potential is offered by the identification, as well as the price, of the characteristics of the assets. This activity is carried out at the early stages of the Real Estate Observatory of the City of Turin – in accordance with the provisions of the standard for the identification of the Microzones – and it has been refined over time. If one refers to the distinction made in Section 1, the survey and analysis of the "characteristics of the neighbourhood" (related to changes in prices and to the intrinsic characteristics of real estate) in fact constitutes an integral part of the methodology for the identification of submarkets (the Microzones) of the city of Turin.

As the experience of Turin shows, the demographic and socio-economic characteristics, the quality of public and private services and environmental and territorial services constitute the three "macro-categories" which together comprise a multitude factors impacting on the pricing of property. For example, the characteristics of the population, interpreted in terms of demographic distribution spatially-related to the city, may be linked to the presence of characteristics appreciated by the population: namely, they may reveal that behaviours in the choice of housing by different demographic categories are attributable to specific characteristics of the dwellings. What is clear is the relationship between prices and local economic conditions, the local occupational structure and type, levels of income. Equally clear is the influence of the quality of services, in particular public services, the quality of the environment (measured indirectly in terms of impact on prices), air quality, noise pollution, transport systems and traffic intensity, climatic-environmental qualities along with physical and topographic characteristics (hilliness, proneness to landslides, presence of green spaces).

Again with reference to Section 2, the second category of effects (adjacency effects) is closely related to the geographical location of the assets; here, the spatial dimension is the primary determinant in the formation of property prices.

The characteristics of the neighbourhood have been the focus of modelling studies and experiments before and after the establishment of the Observatory. The effects of position have been, perhaps, less closely examined.

Based on these premises, it was considered appropriate to choose the city of Turin and its division into Microzones as the field for the experimental application of the proposed model. The model described in Section 3 is applicable, therefore, for purposes of analysing the real estate market in the city of Turin, to identify the component of price variability due to the location factor. The entire city is the basis for the experimentation and, in order to handle the random sample, an approximate analysis is applied, based on the division of the city land in the 40 Microzones.

To summarize what has been said above, the steps of the analysis are as follows:

1. definition of the sample;
2. estimate of probabilities, conditional variances, total variances;
3. estimate of SCPV;
4. identification of the incidence of SCPV on the sample;
5. discussion of the results.

In the following sections we will present the results of each step.

4.1 Define the sample

The sample set up to test the model proposed derives from the data banks of the Real Estate Observatory of the city of Turin (OICT), structured and finalized to monitor the residential asking prices.

In particular, the sample is constituted by asking prices entered in 2008, 2009, 2010 into the following data banks:

1. Residential – Used (RU);
2. Residential – New/Completely renovated (RN).

The RU data bank includes data on already treaded dwellings, while the RN data bank consists of data on new or completely renovated dwellings.

A series of qualitative and quantitative characteristics are registered for every dwelling entered into both data banks. For example:

- asking price;
- area (square metres);
- address;
- Microzone;
- floor;
- number of the rooms;
- description of the rooms;
- number of the bathroom/toilets;
- number of the balconies;
- number of the terraces;
- number of airs;
- preservation level;
- presence of the elevator;
- presence of the concierge service;
- presence of the garage.

One of the most important data related to every dwelling is the "Microzone", because it permits one to monitor the real estate price fluctuations related to each of the 40 Microzones of the city of Turin. In fact, the 40 Microzones could be considered 40 independent sub-markets, fundamental to test the model proposed and to quantify how the location could influence the price of the property.

It is important to underline that the methodology defined to implement the OICT data banks aims first of all to reach a sufficient number of dwellings for every Microzone, in order to guarantee a significant territorial coverage from a statistical point of view. Therefore, the data set has been constituted considering the 40 Microzones in which the city of Turin is subdivided and reaching a minimum of 7 dwellings per semester in every Microzone, so that the statistical outputs could be considered significant. The asking prices entered into the data banks are collected from different specific sources – like the web sites of real estate announcements or specific journals – following a random selection procedure.

For this reason it is possible to affirm that the sample analyzed is random and composed of 40 random and independent sub-samples.

The whole sample is composed of 3179 dwellings; the Tab. 1 shows that, although the data are sampled in order to reach a minimum of 7 units for Microzone, the number of dwellings for every Microzone is rather variable. The reason of this variability is that the territorial areas of the Microzones are not homogeneous, as well as they represent very different sub-markets in typology, price level and trade dynamism. For this reason it is important to underline that the ratios $q_i=n_i/n$, where n_i is the number of dwellings sampled in Microzone i and n is the entire sample size, are used to estimate the weights p_i, as discussed in Section 3.2.

The conditional means and the conditional variances are shown in the Tab. 2 and are expressed respectively in €/mq and (€/mq)^2.

The mean and variance of the whole sample are shown in the Tab. 3.

4.2 Estimate the Spatial Component of Price Variance

In this section we apply the estimation procedure set out in Section 3.2 to the case study, then going on to determine empirically the incidence on the price attributable to the territorial area to which the property belongs. The city of Turin is thus considered as area A and each of its subdivisions into the 40 taxable property Microzones as partition $\{A_1, ..., A_{40}\}$. The empirical *SCPV* is $I^2=44\%$· The data have been elaborated with R.

This result, which highlights the importance of the positional component in the determination of asking prices, supports that the appraisers take into account of location, and in particular of the Microzones segmentation to housing price prediction. The result underline the central role of submarkets starting from the first signal of the housing value, that represents for the buyer an upper bound of his expected gain (rif..).

In order to verify the *SCPV* we estimate it on three subareas.

We suppose that more the Microzones of the subarea differ for characteristics more the sellers and appraisers consider the marginal effect of the belonging to a given Microzone.

The three subareas are clusters of Microzones and they differ for the location characteristics. The first one is spatially homogeneous central, in that we expect for a low I^2 since the Microzones are similar as concerns location (central, neighbouring and small) . The area A is the union of A_1, A_2, A_3, A_4 and $A_{5.}$ We estimate I^2 next to 21%. As concerns the first cluster the result means that the incidence in the price formation due to a change of Microzone is 21%: this is coherent with the choice of a cluster of Microzones very similar for dimension and location.

The second one (Area B) is a semi-central/peripheral cluster of Microzones, i.e. from A_{34} to A_{40}. Again the selected Microzones are neighbouring (exept for Microzone 39, which is one of the less extended of the City), but they cover a wide zone of the city area. We aspect that the sample incidence is bigger. However the

Table 1. The sample: number of dwellings for each Microzone.

Microzone	Name	Number of dwellings
01	Roma	20
02	Carlo Emanuele II	111
03	Solferino	72
04	Vinzaglio	52
05	Garibaldi	104
06	Castello	25
07	Vanchiglia	120
08	Rocca	57
09	Valentino	59
10	San Salvario	40
11	Dante	108
12	San Secondo	72
13	Stati Uniti	7
14	Galileo Ferraris	45
15	De Gasperi	75
16	Duca D'Aosta	3
17	Spina 2 – Politecnico	13
18	Duchessa Jolanda	91
19	S. Donato	113
20	Porta Palazzo	61
21	Palermo	190
22	Michelotti	79
23	Crimea	71
24	Collina	132
25	Zara	34
26	Carducci	81
27	Unità d'Italia	33
28	Lingotto	81
29	Santa Rita – Mirafiori	150
30	Mirafiori Sud	96
31	San Paolo	147
32	Pozzo Strada	113
33	Aeronautica – Parella	149
34	Spina 3 – Eurotorino	101

Microzone	Name	Number of dwellings
35	Madonna Di Campagna	135
36	Spina 4 – Docks Dora	58
37	Rebaudengo	84
38	Corona Nord Ovest	106
39	Spina 1 – Marmolada	25
40	Barca Bertolla	66
City of Turin (whole sample)	3.179	

Table 2. Medium asking prices and variances for every Microzone.

Microzone	Name	Conditional Mean	Conditional Variance
01	Roma	4 625	1 335 571
02	Carlo Emanuele II	4 395	2 250 581
03	Solferino	4 463	908 560
04	Vinzaglio	3 912	1 463 422
05	Garibaldi	3 696	687 610
06	Castello	4 251	580 613
07	Vanchiglia	3 136	655 139
08	Rocca	4 621	2 496 920
09	Valentino	3 569	1 623 040
10	San Salvario	2 245	248 565
11	Dante	3 431	1 849 023
12	San Secondo	3 088	440 111
13	Stati Uniti	4 222	305 098
14	Galileo Ferrarsi	3 693	861 764
15	De Gasperi	3 349	428 545
16	Duca D'Aosta	5 500	26 860
17	Spina 2 – Politecnico	2 901	493 023
18	Duchessa Jolanda	3 253	419 362
19	S. Donato	2 644	691 042
20	Porta Palazzo	2 563	706 547
21	Palermo	2 379	362 895
22	Michelotti	3 377	625 718
23	Crimea	5 094	2 428 398
24	Collina	3 793	1 099 498

Microzone	Name	Conditional Mean	Conditional Variance
25	Zara	2 772	570 452
26	Carducci	2 508	692 203
27	Unità d'Italia	2 445	486 099
28	Lingotto	2 330	295 956
29	Santa Rita - Mirafiori	2 694	321 526
30	Mirafiori Sud	2 137	158 969
31	San Paolo	2 779	359 312
32	Pozzo Strada	3 138	698 893
33	Aeronautica – Parella	2 806	506 823
34	Spina 3 – Eurotorino	2 588	352 762
35	Madonna Di Campagna	2 372	379 980
36	Spina 4 – Docks Dora	1 915	177 844
37	Rebaudengo	2 163	177 196
38	Corona Nord Ovest	2 209	292 587
39	Spina 1 – Marmolada	3 763	643 597
40	Barca Bertolla	2 400	330 162

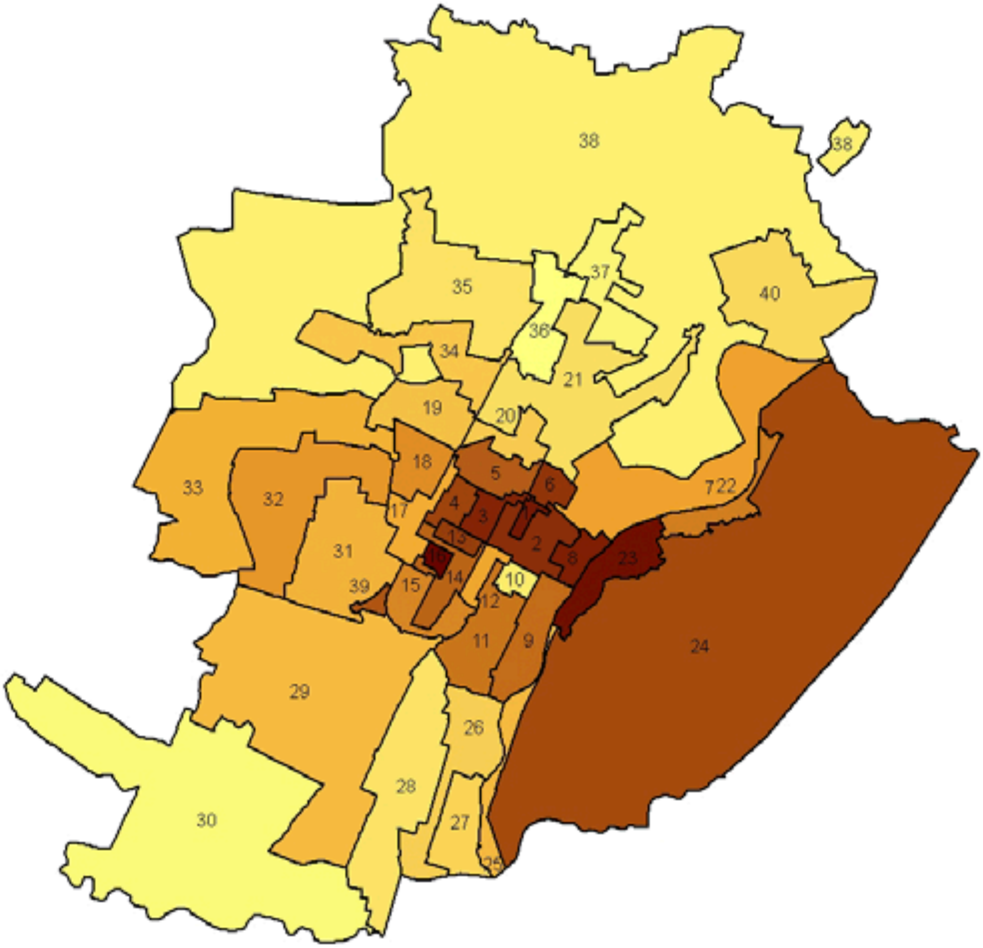
Table 3. Medium asking price and variance of the whole sample.

Name	Medium price	Variance
City of Turin	3 046	1 287 730

incidence is I^2=28%, in that just a little bigger then the previous one. A possible explanation is that the peripheral Microzones are inner heterogeneous, as it will be highlighted in the next section. In that, when a house is listed the location incidence on its value differs for points belonging to the same Microzone, thus the variability between Microzones does not increase too much.

The third area is a cluster with Microzones belonging to locations with different characteristics: A_1, A_{23}, A_{24}, $A_{29,}$ A_{38}. The first one is a central location, while the second and third ones are hill zones. The two last Microzone are peripheral, but one is in the North and the other in the Sud of the city, moreover they are different in dimensions. As concerns this latter cluster we expect a bigger incidence due to the change of Microzone, since the difference between a central and peripheral zone is always significant. The estimated incidence is much higher, in fact I^2=51%, showing that the incidence on asking prices is high if considering areas with different characteristics and amenities. This result highlights that sellers and appraiser understand the marginal effect of location on prices.

Figure 2. The conditional medium asking prices distribution in the 40 Microzones of the city of Turin, Italy (dark brown = higher prices; light yellow = lower prices).



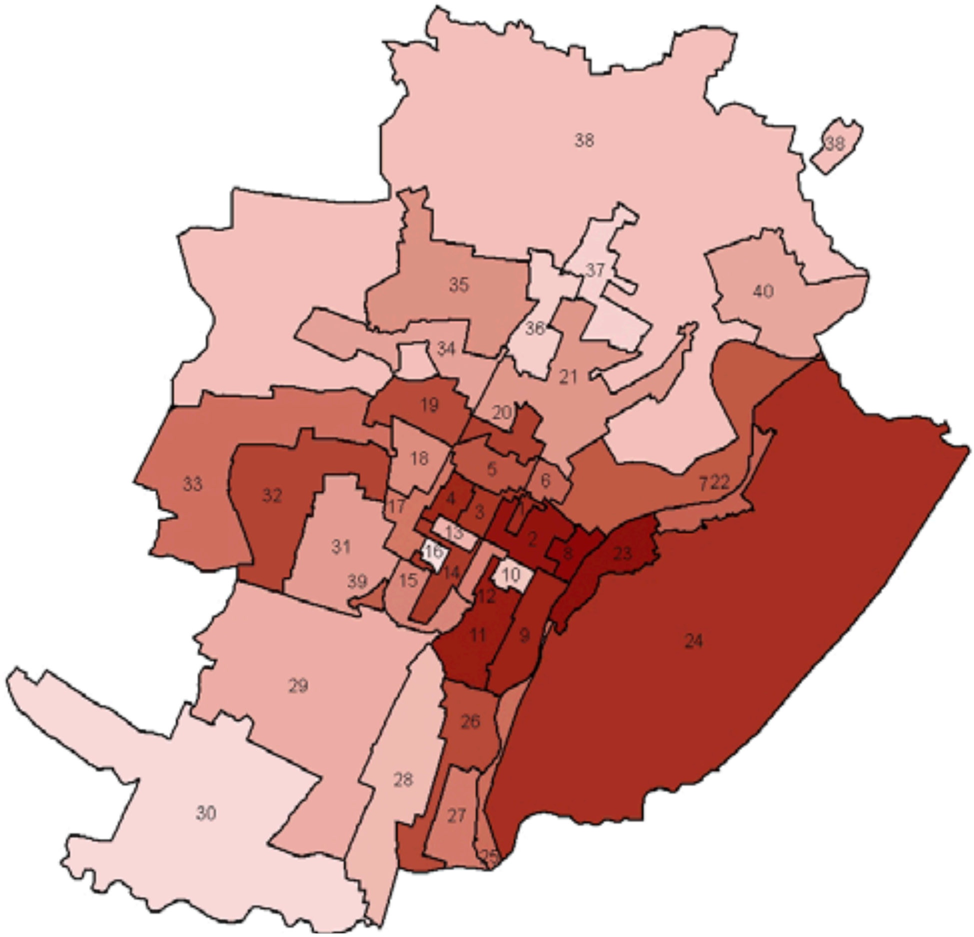
Source: Real Estate Observatory of the City of Turin

In the next section we will develop appropriate interpretations of this result both in relation to the theoretical-methodological framework of reference and with respect to the case study under examination.

5. **Results and economic-estimative considerations**

We now comment in a summary manner on the results of application of the model. The study in question is a first step of a work in progress: one should note that the strength of the results also lies in the various points of departure con-

Figure 3. The conditional variances distribution in the 40 Microzones of the city of Turin, Italy (dark red = higher variances; light rose = lower variances).



Source: Real Estate Observatory of the City of Turin.

tained therein for the development of future research.

We recall that the objective of the trial is to estimate the incidence of position on the price, based on asking prices. The results of the application of the proposed model to the case of Turin shows that the incidence of position on the formation of price is as high as 76% of this price. As explained above, in fact, the spatial component of the price variation (SCPV) amounts to 44%.

This result, which is fairly high, must however be properly interpreted.

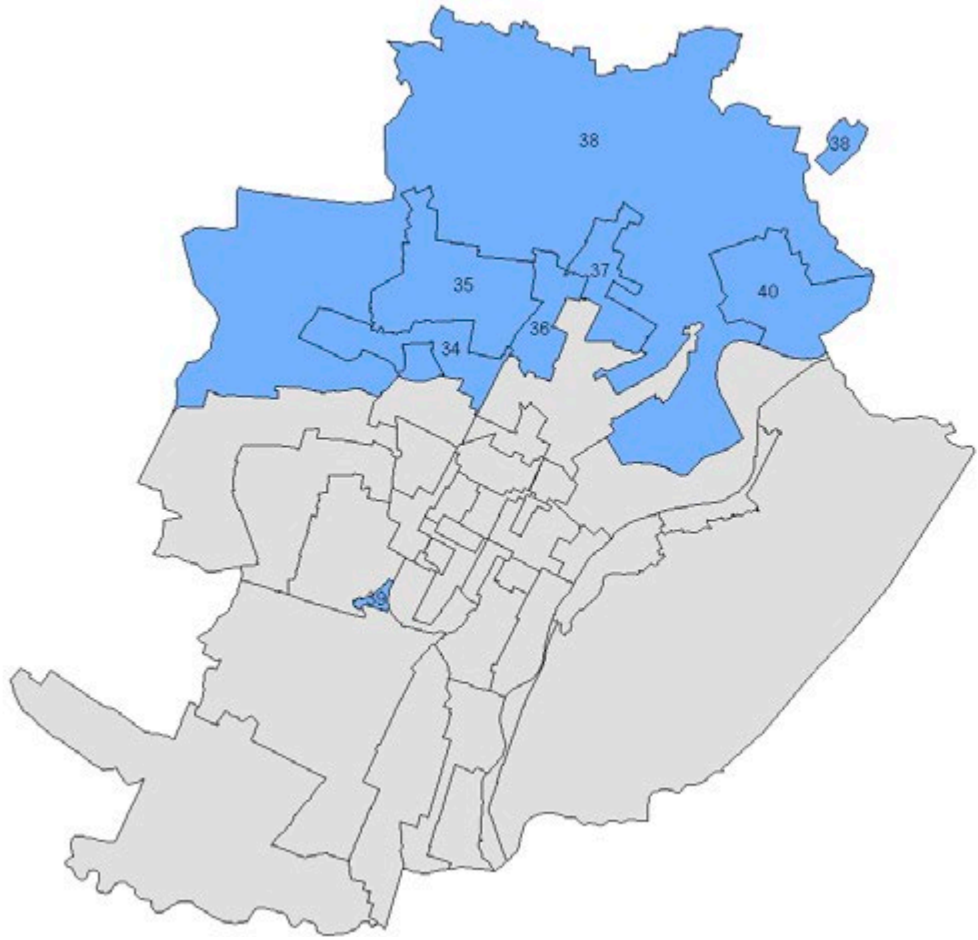
The value of 44% is the percentage calculated on the entire city of Turin: it expresses the percentage change in value that occurs when moving from one point to another in the city (from one Microzone to another), due to the spatial component.

Figure 4. The area A.

Source: Real Estate Observatory of the City of Turin.

As stated in Section 2, in this study, *spatial component* means not only the characteristic related to the location of the property and hence to the area on which the property itself is located, but also the set of all characteristics relevant to the formation of its price: physical-building, architectural, environmental, social characteristics, etc. The percentage portion of pricing that can rightly be attributed to location, however, varies with the change in Microzone in question; with it varies the *weight* (percentage) of the other features that contribute to price formation. For example, the central areas of cities are characterized by a high degree of typological homogeneity and by high prices. One can say that in this case the incidence of the value of the area depends only on the location variable, since the significance of other features is very levelled out: for the central Microzones, the SCPV value achieves high values

Figure 5. The area B.

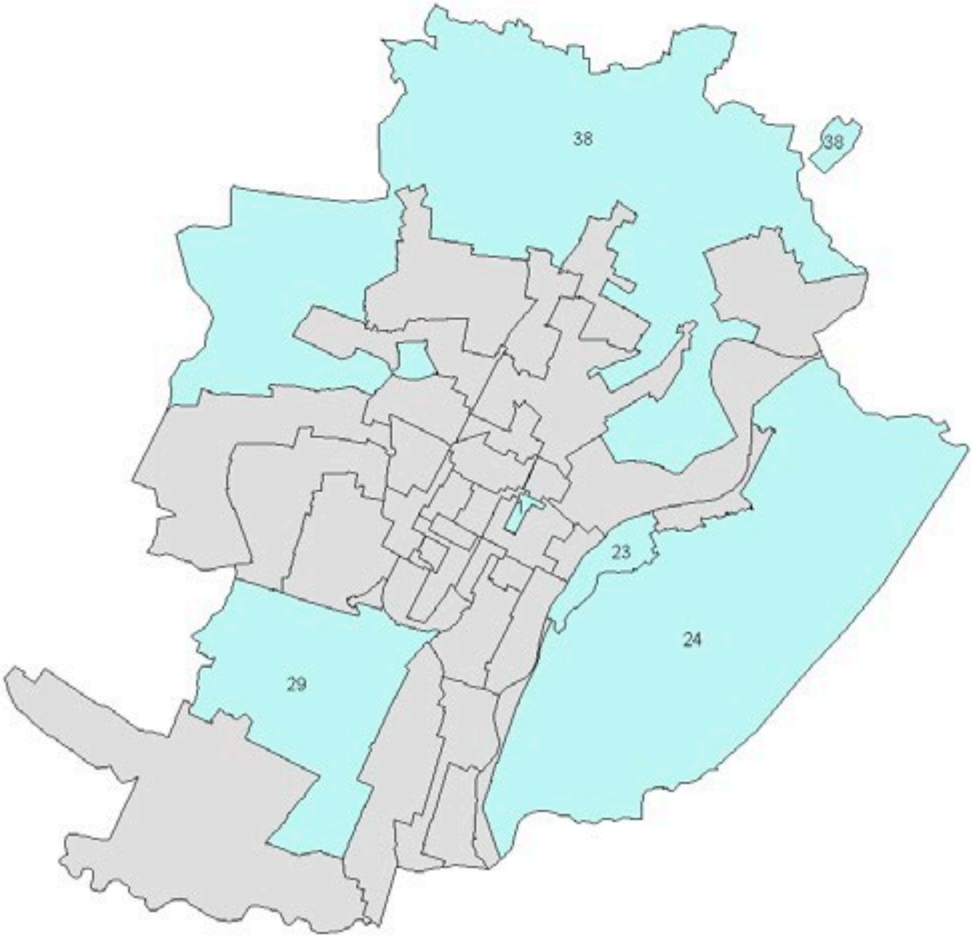


Source: Real Estate Observatory of the City of Turin.

and the variation is entirely attributable to the area on which the real estate assets are located. It remains to be seen whether the behaviour identified for the central areas is confirmed for other portions of the city. The analyses performed in Section 4 – requiring further investigation – in fact show that change the incidence due to varying the location in price is bigger in heterogeneous areas.

At the same time, the remainder of the percentage (we recall that the percentage of the centre cluster -21% – and the peripheral one -28% – are similar even if the peripheral is more heterogeneous) is probably explained by other characteristics: for example, the building type. One may assume that the *weight* of the mix of features is generally higher than that associated with the single area, if we compare with the central Microzones.

Figure 6: The area C.



Source: Real Estate Observatory of the City of Turin.

The interpretation of the result with respect to the central and semi-central or peripheral territorial portions opens up two questions that should be investigated in future studies; both hypotheses should be verified with comparative analysis involving different Microzones (or different clusters of Microzones):

- the behaviour of the central areas suggests the existence of a relationship of proportionality between the homogeneity of the urban fabric, high price levels and the incidence of the positional variable;
- it is possible to hypothesize that the typological heterogeneity of each Microzone is correlated with the variation in the statistical significance of the variable for position and with the variable in statistical significance represented by the other

characteristics. Just as it may be assumed that the *classic* allocation of the value of the asset – yield, cost, area – varies in accordance with the Microzone in question;
- it is necessary to analyse the spatial component of the real estate asset in relation, distinctly, to the segments of the new and second-hand market, since the two *sub-samples* may reveal different behaviours: in the second-hand segment one may assume a behaviour that is more undifferentiated than in the new segment.

The results summarily described give rise to two sets of implications: one of an operational nature, the other of a theoretical-disciplinary kind.

From the technical-operational standpoint, we begin with a consideration already expressed in presenting the model: results of application show a strong degree of influence of the positional characteristic on value. This confirms the usefulness of testing models of spatial statistics, because they can isolate and quantify the effect due to the geographic position of the property. Let us examine its consequences.

The weight which the geographical component of the asset succeeds in capturing, in terms of its explanatory power in relation to price, puts into question the exclusive use of multivariate statistical models if the aim is to achieve a complete identification of the determinants of price. In other words, the application of e.g. the regressive method can attribute only to the intrinsic (of the physical-building type) or micro-environmental characteristics of the assets full relevance in the formation of price. In this way, that incidence - which the spatial model proves is due to the position of the asset - remains *incorporated* in the marginal contribution of the aforementioned characteristics. One may begin by reiterating that the percentage variability of price due to position is attributable to two components. First, the component of value due to position, understood as a portion of the value tied to the area where the asset is located. Secondly, one should consider the effect of the other characteristics which, associated with spatial data, vary in their weight in accordance with variations of position in the territory. Let us try, for example, to base our argument on building typologies; these are presented traditionally as differentiated on the basis of a set of physical and technical characteristics (construction typologies, formal research, content of innovation in the projects and in the materials used, etc.). However, the degree of influence on the price of the building typology changes from one Microzone to another. If, then, the *ordinary* typology of a Microzone is taken to mean the one most frequently occurring therein, it can be said that the *ordinary* dwelling differs in accordance with the variation in the Microzone to which it belongs. The fact that *ordinary* dwelling units vary in the different micro-zones, however, produces certain difficulties; but at the same time is an interesting idea, connected with the theory of submarkets.

The concept of ordinariness, we know, had already become removed from its theoretical significance associated with homogeneity of the typological, construction etc. kind. The city is segmented by stratified territorial areas; sometimes these cross the boundaries of the same Microzones. The way is opened for identifying territorial sub-segments that can be interpreted based on the building typologies and the city planning fabric, reconfiguring the Microzones - within these - or allowing the identification of clusters of Microzones. The way is opened for the interception of stratified samples.

This last idea is linked to a broader debate, which is based on the theory of sub-markets and on microeconomic interpretation. The identification of the determinants of prices of dwellings is in fact conditioned by the functioning of the markets in which they are located. As soon as the real estate market comes to *lose* its form - at least in theory – as a perfectly competitive market, to become a market of monopolistic competition, prices give rise to systems of *differential values*. These are both the result and cause of the mechanisms of formation of sub-markets.

The submarkets, as we know however, do not depend only on the differentiation of commodities but on how subjects are able to select them on the basis of typological, building and of course positional qualities. Then, if the goal is to understand the extent of relevance of spatial characteristics for the purposes of pricing, one must reflect on how consumers behave when they make their purchasing decisions. Similarly, demand behaviour is dependent on supply. Reflection must therefore take into account the complex of market dynamics - supply, demand, prices – based on the elements of transformation of the territory.

About 20 years ago it was noted in Italy that, with the change in conceptions of value and in the methods of formation of prices, it became necessary to adjust the traditional instruments for their measurement. The kernel of the problem, then, was the question of how to measure qualities, monetized by the market (Curto, 1989). On an operational level, discussion was then focused on the impact of the weakening of the yield component and the fragmentation of the market on the applicability of yield procedures and comparative procedures. One innovation made to the instrumental apparatus of the Valuation was made possible by the introduction of hedonic valuation models, developed in the Anglo-Saxon countries since the sixties, to overcome the limits of the procedures based on merit points. The city market was analysed using multivariate statistics and regression models. The market that was then analysed, however, had not yet registered the profound changes that were then to occur, prior to the approval of the General Town Planning Scheme.

Now, it is natural to ask: which elements restore value to the spatial component? What are the causes that trigger the *restoration* of positional characteristics?

An initial response may be seen in the structure of supply. The supply side shows us - in the current post-financial (and economic) crisis since 2008 - a rigid price situation, contracted in terms of the number of transactions and expanded in terms of times of sale. The demand side is strongly conditioned by the effects generated by the General Town Planning Scheme of the city of Turin, in terms of recent or ongoing construction interventions. The General Town Planning Scheme of the city of Turin, since 1995, has implemented a program of urban regeneration on many brownfield sites (large areas with redevelopment problems supported by public funds), along with road and transport interventions and intervention programs for the Olympic Games 2006 implemented through town planning instruments. Through three principal operational lines - reorganization of the road and transport system, urban transformation and regeneration of the central axis and Olympic interventions, environmental / socio-economic renovation and upgrading of peripheral areas - the General Town Planning Scheme has identified a total of 1097 hectares of transformation. To these must be added important future scenarios (variants). All of this has obviously produced economic effects (accompanied by socio-economic changes) and development processes in deteriorated industrial areas. This has encouraged vibrancy in the housing market in areas concerned by the investments and in their territorial micro-surroundings.

This scenario has been conducive to the development of the new/completely restored property submarket, which has surpassed the second-hand segment. The huge quantities placed on the market have been absorbed, contrary to expectations. This seems to give the new real estate segment (at least as a trend factor) the role of controlling prices in the second-hand segment which were reaching excessively high levels. The characteristics of the new real estate segment are monetized in the prices of dwellings and may be justified, at least in part, by elements associated with the spatiality of the building. The new real estate segment is characterized by considerable typological homogeneity and thus a certain homogeneity in the values of the assets (except for differences in building types and location); the second-hand segment is more differentiated and, within it, one may distinguish the sub-segment of period properties, particularly in the central districts.

One may hypothesize that the presence of the new segment has favoured a new dynamic of houses changing in the territory, presenting itself as a concrete alternative choice for demand: this, proving itself to be poorly selective, is not facilitated by very high prices, given the rather low qualities of the dwellings. At the same time it has encouraged an appeal within the city to those strata which were expelled from the Turin market during the nineteen-eighties due to the excessively elevated prices.

The new segment may be the factor that has regulated the market, surpassing the second-hand market which proved less moderate in price levels and less tied to the dynamics of yield. The formation of yield, including positional yield, has instead favoured the supply side. The importance of the newly-built segment is in fact linked to the tendency to always include the components of yield and profit. The interventions have had positive effects on the general income level of the city, even if low compared to other cities. The new segment presents a *hazy* positional yield, becoming part of a city that is clearly no longer in growth. We may assume, to some extent, a reversal in the trend towards rootedness which had characterized the period prior to the General Town Planning Scheme and in the concentration of exchange with districts of origin (already partly disproved with the transfer of strata of demand to outside the city). This is confirmed by the weight given in the literature of the late sixties to positional factors (both intrinsic and extrinsic) - even not attributable to accessibility alone - which are capable of attaining up to 50% of the highest prices: this is not by accident in a context of growth in the construction sector.

Another element that confirms the importance of explaining the effect of positional factors on prices, studied by Anglo-Saxon geographers and economists particularly in the sixties, and then taken up again in the context of hedonic models with particular attention given to Neighbourhood and Micro-neighbourhood quality and which, today, is open to the perspectives of spatial statistics.

6. Conclusion and further research

The importance of the location in determining a property is a central matter in the appraisal theories and practices.

Based on a theoretical and methodological framework, one may analyse the evolution of the estimative studies relating to the central problem of identification and quantification of the determinants of property prices, for purposes of both description and forecasting.

In particular, the present study, based on the concept of *spatial fixity* of real estate, focuses attention on the increasingly important role played by the positional factor in determining price; in fact the latter can no longer be attributed solely to the degree of accessibility of the real estate asset – an argument based on classic urban economic thinking – but must be interpreted in the light of the so-called *neighbourhood effects* and *adjacency effects*.

It is now well accepted that the characteristics of the area where the asset is located, as well as the geographical location of the property itself, significantly affect the formation of its price and, consequently, developments in the housing market of the city or territorial area in question.

In order to calculate how much influence the location of the property has in determining the asking price, it is necessary to refer to the most advanced concept of *spatial structure of the data*, thus resorting to geospatial statistics; applying multivariate statistical models, such as the regressive method, we have in fact seen that the positional factor is difficult to quantify, in that it is *incorporated* in the marginal contribution of the intrinsic (physical / construction) or micro-environmental characteristics of the asset.

The geo-statistical procedure proposed, aimed precisely at quantifying the variability of property appraisal resulting from the location of the real estate assets, thus highlights the importance of the role of location in determining the spatial distribution of asking prices, which leads the dynamics of sales and the choice of consumers.

Data from the real estate market in the city of Turin have confirmed the initial theoretical assumptions which posited the positional factor as the main factor affecting the asset's value listed on the market.

The result, which shows a 44% incidence (calculated for the entire city of Turin), in fact shows a significant decrease in the significance of the other characteristics in the formation of the price.

The relevance of the proposed model is based not only on its potential to isolate the spatial component of the price, but also its on ability to quantify it on the basis of a sample of data related to asking prices. This result therefore shows the great potential of the model to identify the values of areas, analysing only the asking prices of the properties located in them.

The results also suggest interesting potential developments in research, through further applications of the proposed model.

By estimating SCPV for more limited geographical areas (such as the Microzones), it would for example be possible to explain the difference between the different incidences and, therefore, to analyse the variability of the spatial component of the listing price in the central areas of cities compared to peripheral areas.

Other applications of the model could prove useful for investigating, through an appropriate sub-segmentation of the sample, the extent to which the presence of new buildings and / or urban redevelopment has an actual influence in determining the value of the areas in question.

From an estimation point of view, therefore, the advantage of using geo-statistical models is twofold: in general, the greater explanatory power of the model is able to provide more robust analysis of prices and, consequently, more robust estimation. With reference to the specific model proposed here, it resolves the problem of obtaining the incidence of the area based on the prices of the properties alone, thus representing an advance in the process of exploring cutting-edge estimation procedures. At the same time, the use of geo-statistical models has repercussions for knowledge of market dynamics, allowing for more complete interpretations when compared with established approaches.

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