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THE EFFECT OF HYBRID ATTRIBUTES ON PROPERTY PRICES

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Abstract

This study focuses on the sales comparison and the adjustment grid methods, under the framework of the market approach to valuation. The literature mostly focuses on the structural qualities of the properties, referring to the buildings and their locational characteristics, which pertain to their positioning within the urban fabric. Here we focus on a particular set of attributes which depend on how a building is placed in a specific land plot and relate to the surrounding environment. The term «hybrid» is used to identify this class of attributes. It is shown that hybrid attributes affect property prices and should not be disregarded by practitioners and appraisers. The role played by hybrid characteristics is analyzed based on the methodological foundation of the hedonic and the adjustment grid methods. The derived linear and log-linear models are tested by means of a case study. The models prove to have high explanatory power. The weight of each hybrid attribute is estimated to vary between 1% and 10%. Overall, these attributes contribute to 17-23% of the property prices. The validation performed using the grid adjustment method shows that the estimated marginal prices are effective in adjusting the prices per unit area of the comparables.

Key words: *market comparison approach, sales comparison method, adjustment grid method, hybrid attributes, marginal prices*.

JEL Classification: *C13, R30*.

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1. Introduction

When it comes to valuing a real property interest, the conceptual framework of property valuation encompasses a two-layer hierarchical tree of approaches and methods. Three main approaches populate the top level of the hierarchy (IVSC 2017). The cost approach is based on the economic principle of substitution; hence, the estimated value is related to the cost to be incurred in order to obtain an asset of equal utility so that it can replace the subject (RICS 2017). The income approach has its roots in the economic principle of the anticipation of benefits, so that future cash flows are converted into a single current capital value (IVSC 2017). The market approach is grounded in the economic principle of price equilibrium; thus, the value of a subject is identified based on the assumption that identical or similar assets can be found and their price information is available (Parker, 2016).

One or more methods fall under each approach and populate the second level of the hierarchy: the investment, profits, and residual methods as regards the income approach, for instance; the depreciated replacement cost method and the comparable method under the frameworks of the cost approach and market approach, respectively. In addition to this, recent literature suggests that a third, bottom layer can be identified as composed of specific models of valuation (French % Gabrielli, 2018). A model is meant to reflect how and on what basis (x) the market players assess the value (v) of property assets. In other words, a model makes an assumption on the underlying relationship v=f(x) and translates it into a calculation process. As regards the market approach and the comparable method, the hedonic model assumes that consumers value a set of characteristics inasmuch as they shape the perceived utility (Lancaster, 1966; Rosen, 1974); hence, expanding the above notation, v=f(x_j), where j=1,…,m is the set of significant characteristics. It follows that, firstly, the value of assets can be decomposed into the implicit values of their attributes when product differentiation does matter, as in many real estate submarkets. Secondly, differentials in property values are proportional to differences in the quantity and quality of the attributes. Thirdly, using suitable adjustments, those differentials can be removed. The estimation of hedonic pricing functions using statistically sound techniques on large datasets is usual in studies into the determinants of housing prices(Chin & Chau, 2003; Malpezzi, 2003; Páez et al., 2008; Hill, 2012; Mayer et al., 2019). The grid adjustment technique can be seen as an easy-to-use variant of the hedonic model, as it is based on the empirical inference of the adjustments on a limited number of comparables.

Two of the main issues of the grid adjustment technique lie in the identification of the significant attributes - i.e., the characteristics that explain most of the variability in the property values - and the estimation of their marginal prices - namely, the adjustments - both of which are critical tasks left to the discretion of the appraisers. Regardless of the common methodological background, there is actually a paradox in the fact that the hedonic price model lets the data speak for itself, whereas the adjustments must be set a priori. The literature has already suggested several ways to enhance the technique. Nonetheless, this study rests on the hypothesis that there is still room for improvement when it comes to estimating the adjustments. In particular, it aims to show how the estimation can be refined building on a specific class of attributes.

The remainder of this paper is arranged as follows. Section 2 presents a brief perusal of the pertinent literature. Section 3 examines the methodological foundation of the models adopted here. Section 4 illustrates the case study and provides the reader with a description of the data. Section 5 discusses the estimation results and an application meant to validate them. Finally, Section 6 draws the conclusions.

2. Literature review

Early literature on the topic agrees that the grid adjustment technique - and any of its variants, based on functional forms other than the linear one - are among those most widely employed by practitioners and appraisers to estimate the open market value of a subject (Colwell et al., 1983; Isakson, 1986). However, a cynical observer could suggest that the popularity of the technique is proportional to its flaws and drawbacks. The primary reason for concern is the small size of the sample often used for the comparison, which can be either due to a period of weak market activity or a market that is intrinsically thin, thus constantly characterized by a small number of transactions (French & Gabrielli, 2004). Besides, the marked heterogeneity of the properties traded in the local submarket can exacerbate the issue (LaCour-Little & Green, 1998; Tajani et al., 2020).

Scarcity aside, data quality and reliability are additional key issues (Scarrett, 1996; Simonotti et al., 2016). It has been shown that the selection process of comparables can be biased due to the fact that appraisers are likely to over-weigh the empirical data they find first, and vice versa for the data that comes to their attention later (Lin & Chang, 2012).

Furthermore, it has long since been recognized that subjectivity and uncertainty are inherent features of the technique (Colwell et al., 1983; Lipscomb & Gray, 1990), especially when it comes to the reconciliation of the values of the comparables with respect to the subject. This is because the estimation of the adjustment factors is usually based "upon some sort of market insight obtained through years of experience" (Isakson, 1986, p. 275). Different perceptions about the role of qualitative housing characteristics and the lack of standardized measurement methods further exacerbate the subjectivity issue (Foryś & Gaca, 2020). It has also been argued that the attribute-by-attribute comparison can occasionally lead to misleading results, namely, overall adjustments with different signs than those one could expect by considering the comparable as a whole (Rodgers, 1994).

Several attempts to overcome the limitations of the grid adjustment technique can be found in the literature. A specific research strand focuses on the adoption of mathematically and statistically sound methods to identify the comparables and infer the adjustment factors. To properly select the subset of comparables among all traded properties that are somewhat similar to the subject, several improvements have been suggested: a criterion based on the notion of Mahalanobis distance (Isakson, 1986), the Mahalanobis distance modified by adding a geographic distance penalty (Krause & Kummerow, 2011), and a process founded on "the minimum variance among the adjusted value estimates of sales" (Vandell, 1991, p. 219; Gau et al., 1992; Green, 1994). In addition to this, the estimation of the adjustments using multiple regression models has been repeatedly suggested (Kang & Reichert, 1991; Lentz & Wang, 1998), subject to the availability of sufficient data (Colwell et al. 1983). Recent studies suggest that the estimation of attributes' weights can be improved and optimized by simultaneously using several correlation measures (Doszyń, 2017; Gaca, 2018; Barańska, 2019) or the residuals of hedonic models (Doszyń & Gnat, 2017).

The estimation of the adjustments based on traditional OLS (ordinary least squares) may be inefficient due to errors that are not independent and identically distributed; hence, the literature has tested alternative estimators based, for instance, on GLS (generalized least squares) procedures (Pace, 1998) and models resembling the SAR (spatial autoregressive) ones (Pace & Gilley, 1998). Other authors propose a variant of the sales comparison approach based on the notion of a spatial weights matrix - which is distinctive of SAR models - and argue that it has significant relationships with the GWR (geographically weighted regression) method (Borst & Mccluskey, 2008).

Radical solutions aside, such as abandoning the comparison based on specific attributes and substituting it with an overall property-to-property comparison (Rodgers, 1994), other authors suggest resorting to different methods, such as those borrowed from multicriteria decision support systems. Under this framework, a recent study suggests improving the process meant to weigh the comparables by using "the [Choquet integral] as an operator of their adjusted prices, working with non-linear fuzzy measures of attributes" (Özdilek, 2020, p. 98).

3. Method and models

3.1. Conceptual framework

The so-called "utility-bearing attributes or characteristic" (Rosen, 1974, p. 34) of properties "have traditionally been divided into structural attributes and locational attributes" (Orford, 1988, p. 1). According to this setting, and building on previous works (Guerin, 2000; Gloudemans, 2001), two studies published during the last decade discuss empirical applications of the hedonic-based apportionment technique, where the attributes are clustered into two groups: on the one hand, the land-related features; on the other hand, the building characteristics (Özdilek, 2012, 2016). Under the same framework, a recent study first deducted the expected construction costs from observed sale prices of new homes in a metropolitan area. The resulting land values - adjusted according to differences in lot size - are applied to all the land parcels in a given zip code area (Davis et al., 2017). Indeed, it is relatively easy to find information about the weights of the main locational attributes since they "are indeed capitalised in land values" (Kauko, 2003, p. 253). Accordingly, a rough estimation of the overall weight of locational features can be inferred by the ratio between the land value and the market value of a property (Davis & Heathcote, 2007; Davis & Palumbo, 2008; Oliner et al., 2010), a parameter that has been called "land leverage" (Bostic et al., 2007, p. 184). Equally, the weights of primary structural attributes can be approximated referring to cost data, namely, based on the construction costs of the building components (Davis & Heathcote, 2007; French & Gabrielli, 2007; Davis & Palumbo, 2008).

An additional third group of attributes can be identified between the classes that include the locational and building features. They are seldom highlighted in studies of the real estate market, often neglected in hedonic models, and almost always hard to weigh. Nevertheless, studies dealing with this third class of attributes can be occasionally found in the literature.

An early study focuses on the multiple roles of balconies in shaping property values (Wing Chau et al. 2004). At the same time, they serve as additional available space, a green provision but also a security concern. Accordingly, the attribute defined as the presence or absence of one or more balconies can hardly be said to pertain to building features exclusively. Instead, it is among those physical features of the building that interacts with its locational characteristics.

Another study focuses on the floor a flat is located on. That attribute partly relates to structural features when considering the time required to get in or get out of the building, and the perceived "substitutability between staircases and lifts" (Wong et al., 2011, p. 34). Simultaneously, it also interacts with locational attributes with regard to social and environmental quality, so that "units on lower floors … suffer more from environmental problems, including air pollution, noise, lack of views, and security risk" (Wong et al., 2011, p. 34).

Another pertinent example is the attribute broadly defined as panoramic view (comprehensive literature reviews on the value of view characteristics in hedonic studies can be found in Bourassa et al. (2004) and Baranzini and Schaerer (2011)). In an analysis of the value of the panoramic view that one can be enjoyed from a property unit, a distinction is made where the locational attributes are concerned. On the one hand, fixed urban amenities characterize all the properties in a neighborhood. On the other hand, "relative locational attributes are specific to the precise dwelling location" (Jayasekare et al., 2019, p. 144). The view of nearby amenities is included in the second cluster because it "is a function of location's attributes in the 3D space such as surrounding land use and terrain" (Jayasekare et al., 2019, p. 145). Hence, it can be argued that the panoramic view depends on how a building specifically interacts with the surrounding environment, which also explains why it is hard to measure and has been assessed in previous studies using a variety of methods and variables (Bourassa et al., 2004).

Attributes such as those listed above - and others as well, like the main orientation of the building, for instance - are defined here as «hybrids,» meaning that they arise from the interrelationship of location and structure. In other words, those attributes depend on how a building is placed in a specific land plot and relates to the surroundings. The next subsection is devoted to defining specific analytical models, which are useful to delve into estimating the weights of the hybrid amenities.

3.2. Analytical models

The methodological foundation of the hedonic price method, which is also shared by the variants of the adjustment grid method (Colwell et al., 1983), is adopted in this study. Accordingly, the relationship between property price and attributes is analyzed using the following function:

$$Up = \alpha + \beta Sa + L\gamma + S\delta + H\theta + \varepsilon \tag{1}$$

where *Up* stands for the asking price per unit area, α is the constant, *Sa* is the gross saleable area and β is its coefficient, *L*, *S*, and *H* are three vectors of structural, locational, and hybrid attributes, γ, δ, and θ are their coefficients, and ε is the error term. The residuals are assumed to be near normally distributed around mean zero; hence, $X \sim N(0, \sigma^2)$.

In the matched pair adjustment method, the comparables are ideally chosen so as to differ in one attribute only. Accordingly, "the difference in the sale prices of these ... properties can be attributed solely to that one feature and represent the adjustment amount for the presence (absence) of that feature" (Lipscomb & Gray, 1990, p. 53). Similarly to a previous study (Krause & Kummerow, 2011), let us suppose that the comparables are chosen so as to exactly share the same locational (*L*) and structural (*S*) attributes of the subject. Namely, the comparables are built in the same area and in the same way as the subject. Accordingly, the previous form of Eq. (1) can be rewritten as follows:

$$Up = \alpha + \beta Sa + \overline{L\gamma} + \overline{S\delta} + H\theta + \varepsilon \tag{2}$$

Thanks to this assumption, although the terms $L\gamma$ and $S\delta$ are not superfluous in shaping the property market value, they can be omitted since they collapse into the constant term α. Indeed, the attributes that "are identical between the subject and comparable property … can be omitted from the price differences model", while only the "characteristics that vary between properties need be included” (Krause & Kummerow, 2011, p. 41). In other words, α is going to represent the market appreciation for the invariant locational and structural attributes and Eq. (2) reduces to:

$$Up = \alpha + \beta Sa + H\theta + \varepsilon \quad (3)$$

As far as vector H is concerned, let us consider the following hybrid attributes: Fl (floor level), Ph (penthouse), Os (open sides), Pw (panoramic view), and mO (main orientation) so that previous Eq. (3) can be expanded as follows:

$$Up = \alpha + \beta_1 Sa + \beta_2 Fl + \beta_3 Ph + \beta_4 Os + \beta_5 Pw + \beta_6 mO + \varepsilon \quad (4)$$

where θ_j (with j=1,…,5) are the coefficients measuring the marginal price of each characteristic, which can be converted into percentage weights - namely, the percentage changes in the price (Up) - based on the average value of the attributes and the average asking price per unit area:

$$\Delta Up = \theta_j \overline{H_j} / \overline{Up} \quad (5)$$

Building on the previous Eq. (3) and omitting the error term ε, the difference between the estimated price of the subject s and the observed price of the ith comparable can be derived as follows:

$$\widehat{Up}_s - Up_i = \beta(Sa_s - Sa_i) + \sum_{j=1}^{5} \theta_j (H_{j,s} - H_{j,i}) \quad (6)$$

Hence, the estimated price of the subject is:

$$\widehat{Up}_s = Up_i + \beta(Sa_s - Sa_i) + \sum_{j=1}^{5} \theta_j (H_{j,s} - H_{j,i}) \quad (7)$$

A variant of the linear model of Eq. (3) is the log-linear one, where the dependent variable in the left-hand side of the equation is the natural logarithm of the price:

$$\ln(Up) = \alpha + \beta Sa + H\theta + \varepsilon \quad (8)$$

Many hedonic studies use the natural logarithm of the dependent variable. That implies the assumption of a nonlinear or semi-linear relationship (Copiello, 2020); besides, it helps address common issues since it mitigates heteroskedasticity and makes the distribution of the residuals more normal (Bourassa et al., 2004). The coefficients of the log-linear model represent the percentage change in the price (Up) commanded by a unit variation of the attributes, according to the following calculation that has been suggested in the literature (Halvorsen & Palmquist, 1980):

$$\Delta Up = e^{\theta j} - 1 \quad (9)$$

4. Data

4.1. Overview of the case study

The case study we use to test the models is Borgo Berga (Fig. 1) in the city of Vicenza, Northeastern Italy, a brownfield site formerly hosting the Rossi cotton mill (also known as Cotorossi by the locals, left panels of Fig. 2) and recently redeveloped into a mixed-function district. The redevelopment project has been carried out through a public-private partnership. It was formalized with the signing of an integrated intervention plan (Stanghellini & Copiello, 2011), where an agreement on the town planning rules for the area was established between a public body (the municipality) and a private entity (the developer Sviluppo Cotorossi Plc, a joint subsidiary of the construction and real estate firms Maltauro Immobiliare Ltd - now part of ICM Group Plc - and Codelfa Plc). The plan has undergone severe criticism due to its alleged speculative, profit-seeking nature (Fregolent & Tedesco, 2016; Franzina, 2017), but this goes beyond the scope of this study.

Designed by the architects Gonçalo Byrne and João Nunes, the project has been developed starting from the mid-2000s. It features residential, commercial, and business blocks on the privately-owned area of about 53 hectares and the city’s new courthouse on the publicly-owned area of about 46 hectares (right panels of Fig. 2). The project is expected to be concluded in the forthcoming years, although delays are on the horizon for the southeastern extension.

Fig. 1. Borgo Berga redevelopment project in the city of Vicenza, Northeastern Italy (in the upper right frame is the boundary of the already built residential, commercial, and business blocks). *Source*: Google Earth and the Municipality of Vicenza.

Fig. 2. The former Rossi cotton mill (left panels) and Borgo Berga redevelopment project (right panels). *Source*: the Municipality of Vicenza, the construction firms, and local newspapers and associations.

4.2. Overview of the analyzed data

A search conducted in January 2020 has led to identifying 14 residential properties listed for sale in Borgo Berga. They are homogeneous as far as their location is concerned, and identical as regards their structural characteristics, i.e. the construction materials used. In addition to this, they share the following finishes and systems: dyed-durmast floors and porcelain stoneware floors, mosaic walls in the bathrooms, video surveillance, district heating, floor heating system and air conditioning, and thermal-break frames. All the residential units are assigned the A energy rating band. Underground garages and basements can be purchased separately.

The properties only differ in size and in terms of the set of hybrid attributes analyzed here (Tab. 1). The fact that the properties are identical in every respect as far as location and construction are concerned, enables us to focus on the role played by the hybrid attributes, as it can be assumed they are the only reason behind the changes in prices, gross saleable area aside.

There are remarkable differences in size since the sample includes both a 49 m² studio flat and four- or five-room apartments of more than 200 m². This also means that the properties have different numbers of bedrooms and bathrooms. Furthermore, they are sometimes equipped with small balconies, and other times with large terraces. However, these dimensional attributes are all strongly correlated with the gross saleable area (Tab. 2). The large difference in the gross saleable area raises the issue of whether the housing units belong to different market segments. Incidentally, the two studio flats and the two other small dwellings (47-49 m² and 70-73 m², respectively) share similar hybrid attributes: all on the ground floor, an ordinary panoramic view, two open sides, with none of them facing south. Hence, it could be hypothesized that hybrid attributes play a minor role for the market players interested in small flats. However, their inclusion in the dataset is important concerning the sample size and also provides an adequate representation of certain qualities of the hybrid attributes - e.g., north-facing ground floor flats.

According to the descriptive statistics (Tab. 3), the average asking price per unit area *Up* is equal to about 2,540 Euros/m², in keeping with the information included in other sources. For instance, the Real Estate Market Monitor of the Italian Revenue Agency shows that - in the same area, between late 2019 and early 2020 - the price of new houses can be expected to vary between 2,250 and 2,400 Euros/m². Besides, a report published in the first semester of 2019 in Italy's leading financial newspaper, Il Sole 24Ore, points to a value in the range between 2,500 and 2,700 Euros/m².

Table 1

List of the attributes

Variable	Definition	Unit of measure
Up	Price per unit area	Euros/m²
Sa	Gross saleable area	m²
Fl	Floor level	count
Ph	Penthouse	dichotomous (a)
Os	Open sides	count
Pw	Panoramic view	trichotomous (b)
mO	Main orientation	multinomial (c)

(a) 0: no, 1: yes; (b) -1: ordinary, 0: extra-ordinary (view over the surrounding hills), 1: superb (view over the Palladian Villa "La Rotonda"); (c) 1: North-east or North-west, 2: East, 3: South-east or South-west, 4: South.

Source: own calculations.

The minimum *Up* is 1,918 Euros/m², while the maximum is 3,286 Euros/m². Such a big difference - about 71% - for a set of properties sharing the same locational and structural characteristics could mean that the hybrid attributes really do matter when it comes to shaping the prices.

More than half of the properties (8 out of 14) are located on the ground or first floor; two are penthouses. It has been suggested in the literature that the relationship between housing price and floor level is best described by using a nonlinear function (Wong et al., 2011; Xiao et al., 2019). However, a test run on the dataset shows no clear evidence that a nonlinear model outperforms the linear one. Open sides range from two (mostly) to three (occasionally). About one-third of the flats benefit from a better-than-average panoramic view. The most common orientation is East to Southwest.

Table 2

Correlations between the gross saleable area and other dimensional attributes

	Sa	tR (a)	bR (b)	Bt (c)	nT (d)	aT (e)
Sa	1					
tR (a)	0.87 (0.0000)	1				
bR (b)	0.90 (0.0000)	0.94 (0.0000)	1			
Bt (c)	0.92 (0.0000)	0.86 (0.0001)	0.85 (0.0001)	1		
nT (d)	0.91 (0.0000)	0.87 (0.0001)	0.78 (0.0009)	0.82 (0.0003)	1	
aT (e)	0.59 (0.0268)	0.29 (0.3126)	0.38 (0.1748)	0.45 (0.1077)	0.38 (0.1761)	1

In brackets below the coefficients are the p-values. (a) Total rooms; (b) Number of single and double bedrooms; (c) Number of bathrooms; (d) Number of balconies and terraces; (e) Area of balconies and terraces

Source: own calculations.

Table 3

Descriptive statistics

Quantitative variables						
		Mean		Standard deviation		Minimum - Maximum
Up		2,541		408		1,918 – 3,286
Sa		137		64		47 - 253
Hybrid attributes						
Values	-1	0	1	2	3	4
Fl		28.6%	28.6%	21.4%	14.3%	7.1%
Ph		78.6%	21.4%			
Os				64.3%	35.7%	
Pw	57.1%	14.3%	28.6%			
mO			35.7%	7.1%	28.6%	28.6%

Source: own calculations.

5. Results and discussion

5.1. Weight estimation of the hybrid attributes

The models of Eqs. (3) and (8) are fitted using a Maximum Likelihood (ML) estimator and assuming the normal distribution of the dependent variable, that is to say, the asking price per unit area. Since ML estimators perform poorly in small samples, which implies biased results, Ordinary Least Squares (OLS) are also used, leading to similar estimates. The linear model of Eq. (3) does not suffer from departure from normality (H_0: errors are normally distributed, Chi-square(2) 0.306, p-value 0.8581) although the distribution of the standardized residuals is slightly skewed (Fig. 3). The log-linear model of Eq. (8) is even less affected by the same issue (Fig. 4), though the error term distribution is still slightly skewed (Chi-square(2) 0.111, p-value 0.9460). It is worth discussing the results of both models.

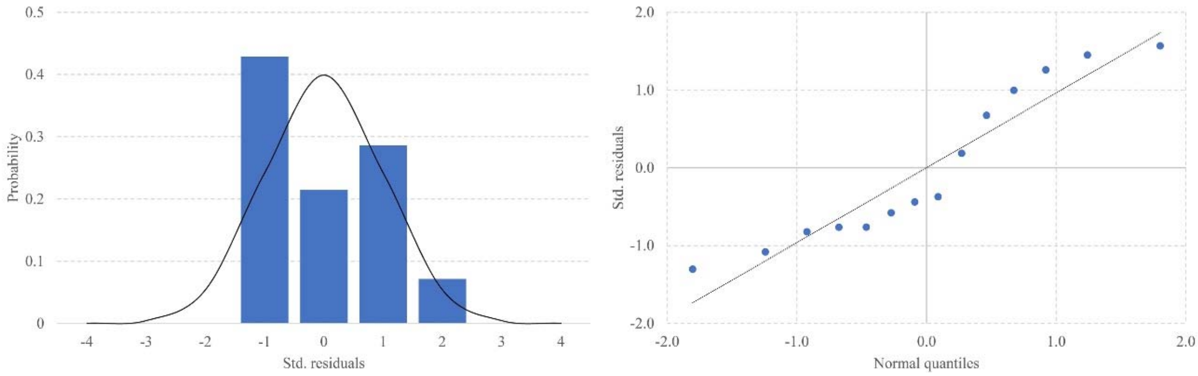

Fig. 3. Normal distribution (left panel) and Q-Q plot (right panel) of the residuals in the linear model. *Source*: own study.

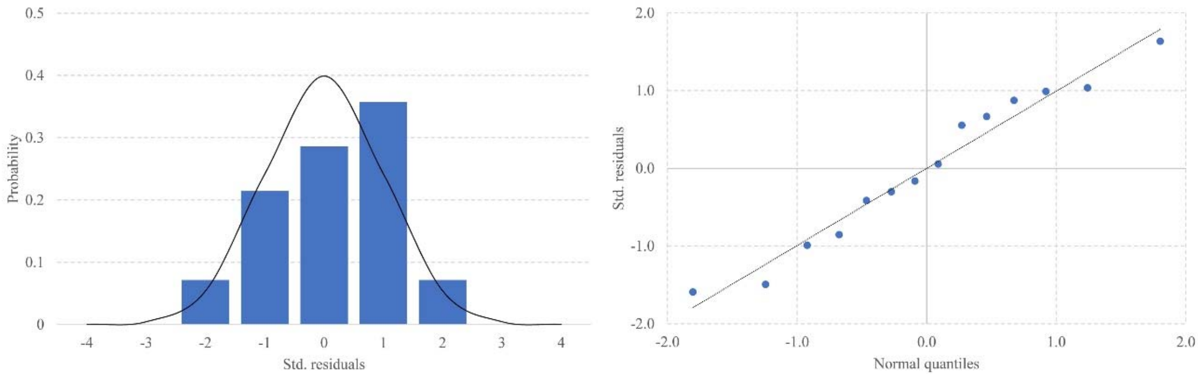

Fig. 4. Normal distribution (left panel) and Q-Q plot (right panel) of the residuals in the log-linear model. *Source*: own study.

Concerning the linear model of Eq. (3), the covariates *Ph* and *Pw* are omitted because their coefficients are either equal to zero or so close to zero as to have a negligible influence on the property price. The results are as follows (in brackets below, the coefficients are the p-value and the significance level according to the likelihood ratio test; H_0: the predictor is not significant; significance levels: * 10%; ** 5%; *** 1%):

$$\underset{(0.0000\ ***)}{Up = 1{,}762.58} + \underset{(0.0658\ *)}{1.33}\ Sa + \underset{(0.0015\ ***)}{183.68}\ Fl + \underset{(0.1549)}{64.74}\ Os + \underset{(0.0681\ *)}{71.53}\ mO \tag{10}$$

As regards the log-linear model of Eq. (8), only the covariate *Ph* is omitted because its coefficient is equal to zero, although other predictors have low statistical significance. The estimation results are as follows:

$$\underset{(0.0000\ ***)}{Up = 1{,}762.58} + \underset{(0.0658\ *)}{1.33}\ Sa + \underset{(0.0015\ ***)}{183.68}\ Fl + \underset{(0.1549)}{64.74}\ Os + \underset{(0.0681\ *)}{71.53}\ mO \tag{11}$$

Both models have high explanatory power: the pseudo-R^2 - namely, the coefficient of determination, calculated as the squared correlation between the observed values and the predicted ones according to its most general definition (Everitt & Skrondal, 2010) - is equal to 0.8999 (0.8554 adjusted by the degrees of freedom) and 0.8855 (0.8140 adjusted by the degrees of freedom), respectively.

The regression coefficients are converted into percentage weights according to Eq. (5) for the linear model and Eq. (9) for the log-linear one. The models agree on the weight of *Fl*, about 10%, while they show divergent results for the other hybrid attributes. *Os* is worth up to 6% of the asking price per unit area in the linear model of Eq. (3) against barely half in the log-linear model of Eq. (8). The gap is still wider for *mO*: from 7% to less than 1%. The market appreciation for *Pw*, about 4%, is confirmed in the log-linear model only. The total weight of the hybrid attributes varies from 23.4% to 16.9% (Tab. 4).

Table 4

Percentage weights of hybrid attributes over the asking price per unit area

Hybrid attribute	Linear model	Log-linear model
Fl	**10.3%**	**9.3%**
Ph	-	-
Os	6.0%	2.8%
Pw	-	4.0%
mO	**7.0%**	0.8%
Total	23.4%	16.9%
Statistically significant values are highlighted in bold		

Source: own calculations.

Regarding the apportionment of the asking price per unit area, let us consider that the land leverage in central and inner ring areas of the city of Vicenza is estimated to vary between 28% and 38% - 33% on average - according to the technical journal Consulente Immobiliare, a biweekly publication of the Sole 24Ore group (see Issues 1011, 15.12.2016, p. 2074). Therefore, given the estimated weight of the hybrid attributes, the building value can be expected to range between 44% and 50% of the asking price per unit area (Fig. 5). Considering an average asking price per unit area of about 2,540 Euros/m^2 as reported in Section 4, this implies a lower bound of the building value of approximately 1,100 Euros/m^2, and un upper bound of about 1,275 Euros/m^2. These values are in keeping with the figures that can be found in the building cost books focusing on the Italian construction industry (Milan Board of Engineers and Architects 2019)

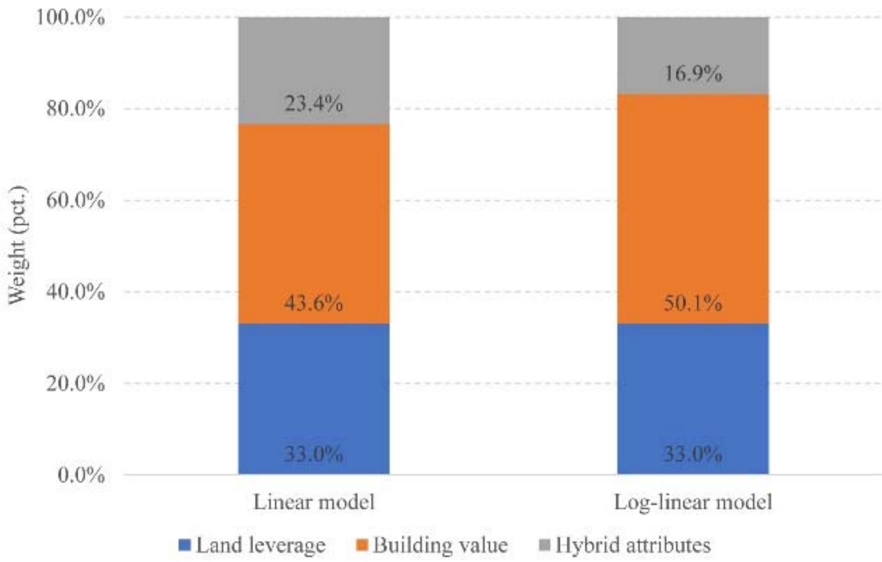

Fig. 5. Apportionment of the asking price per unit area. *Source*: own study.

5.2. Validation through the adjustment grid method

The estimated coefficients of the hybrid attributes have been employed to develop the grid adjustment method for validation purposes. The comparable E is used as the benchmark, assuming its price is unknown, similarly to the subject's price. The estimation is performed according to Eq. (6).

The marginal prices are effective in adjusting the asking prices per unit area of the comparables upwards and downwards (Tabs. 5 and 6). The deviation from the average value varies from -24% to 30% where the original asking prices are concerned. After reconciliation, the divergence from the average falls in the range of ±10%. It is worth noting that the linear model is more effective than the log-linear one. On the one hand, it leads to a narrow range of adjusted prices, which is smaller in comparison to that resulting from the logarithmic transformation (Fig. 6). On the other, it leads to an estimated price for the Comparable E that is closer to the actual observed price: the estimated price per unit area is 2,638 Euros/m² in the linear model (-1.0%) against 2,580 Euros/m² in the log-linear one (-3.2%).

6. Conclusions and further developments

The real estate literature has paid considerable attention to two primary drivers of the property prices: the structural qualities of the properties on the one hand, i.e., those referring to the building, and their locational characteristics on the other hand, namely, those pertaining to its positioning in the urban fabric. It can be assumed that the properties that share the same structural and locational attributes - since they are built in the same area and in the same way - are close substitutes. This assumption is likely to hold true when the class of hybrid attributes, defined as those arising from the mutual relationships between location and structure, does not play a significant role in shaping the property prices.

The case study analyzed here shows that characteristics, such as floor level, open sides, a panoramic view, and main orientation should not be neglected, as their overall weight may be up to a fourth of the property price. Hence, for the sake of reliability, hybrid attributes should be thoroughly considered by practitioners and appraisers in the valuation process and especially in the comparison adjustment process.

Table 5

Grid adjustment method using the marginal prices estimated in the linear model

		Up	Dev.	Sa	Fl	Os	mE	SAdjust.	AdjUp	Dev.
	(a)		(b)					(c)	(d)	(e)
Marginal	price			1.33	183.68	64.74	71.53			
Comp. A	D			40	1	1	-2			
	D·Mp	2,676	6%	53	184	65	-143	159	2,835	7%
Comp. B	D			-28	-1	0	-3			
	D·Mp	3,286	30%	-37	-184	0	-215	-436	2,850	8%
Comp. C	D			47	1	1	-2			
	D·Mp	2,370	-6%	63	184	65	-143	169	2,539	-4%
Comp. D	D			73	1	1	0			
	D·Mp	2,385	-6%	97	184	65	0	346	2,731	4%
Comp. E (subject)	D			0	0	0	0			
	D·Mp			0	0	0	0			
Comp. F	D			39	0	1	0			
	D·Mp	2,657	5%	52	0	65	0	117	2,774	5%
Comp. G	D			-21	0	0	-3			
	D·Mp	2,833	12%	-28	0	0	-215	-243	2,590	-2%
Comp. H	D			-71	-2	0	-3			
	D·Mp	3,142	24%	-94	-367	0	-215	-676	2,466	-7%
Comp. I	D			88	1	1	-2			
	D·Mp	2,340	-8%	117	184	65	-143	223	2,563	-3%
Comp. J	D			133	2	1	-1			

	D·Mp	2,000	-21%	177	367	65	-72	537	2,537	-4%
Comp. K	D			112	2	1	0			
	D·Mp	2,000	-21%	149	367	65	0	581	2,581	-2%
Comp. L	D			135	2	1	-2			
	D·Mp	2,340	-8%	180	367	65	-143	469	2,809	6%
Comp. M	D			109	2	1	0			
	D·Mp	1,918	-24%	145	367	65	0	577	2,495	-5%
Comp. N	D			-21	-1	0	-3			
	D·Mp	2,956	17%	-28	-184	0	-215	-427	2,529	-4%
Average		2,531							2,638	

(a) For each comparable, D is the difference with the subject, and D·Mp is the difference multiplied by the marginal price; (b) Deviation from average, before adjustments; (c) Sum of the adjustments; (d) Adjusted unit price; (e) Deviation from average, after adjustments.

Source: own study.

Table 6

Grid adjustment method using the marginal prices estimated in the log-linear model

		Up	Dev.	Sa	Fl	Os	Pw	mE	SAdjust.	AdjUp	Dev.
	(a)		(b)						(c)	(d)	(e)
Marginal	price			0.0000	0.0893	0.0274	0.0390	0.0079			
Comp. A	D			40	1	1	-2	-2			
	D·Mp	2,676	6%	0.0004	0.0893	0.0274	-0.0780	-0.0158	0.0232	2,739	6%
Comp. B	D			-28	-1	0	-2	-3			
	D·Mp	3,286	30%	-0.0003	-0.0893	0.0000	-0.0780	-0.0237	-0.1913	2,714	5%
Comp. C	D			47	1	1	-1	-2			
	D·Mp	2,370	-6%	0.0005	0.0893	0.0274	-0.0390	-0.0158	0.0623	2,522	-2%
Comp. D	D			73	1	1	0	0			
	D·Mp	2,385	-6%	0.0007	0.0893	0.0274	0.0000	0.0000	0.1174	2,682	4%
Comp. E (subject)	D			0	0	0	0	0			
	D·Mp			0.0000	0.0000	0.0000	0.0000	0.0000			
Comp. F	D			39	0	1	0	0			
	D·Mp	2,657	5%	0.0004	0.0000	0.0274	0.0000	0.0000	0.0277	2,732	6%
Comp. G	D			-21	0	0	-2	-3			
	D·Mp	2,833	12%	-0.0002	0.0000	0.0000	-0.0780	-0.0237	-0.1019	2,558	-1%
Comp. H	D			-71	-2	0	-2	-3			
	D·Mp	3,142	24%	-0.0007	-0.1786	0.0000	-0.0780	-0.0237	-0.2810	2,372	-8%

Comp. I	D			88	1	1	0	-2			
	D·Mp	2,340	-8%	0.0009	0.0893	0.0274	0.0000	-0.0158	0.1017	2,590	0%
Comp. J	D			133	2	1	0	-1			
	D·Mp	2,000	-21%	0.0013	0.1786	0.0274	0.0000	-0.0079	0.1993	2,441	-5%
Comp. K	D			112	2	1	0	0			
	D·Mp	2,000	-21%	0.0011	0.1786	0.0274	0.0000	0.0000	0.2071	2,460	-5%
Comp. L	D			135	2	1	0	-2			
	D·Mp	2,340	-8%	0.0013	0.1786	0.0274	0.0000	-0.0158	0.1914	2,834	10%
Comp. M	D			109	2	1	0	0			
	D·Mp	1,918	-24%	0.0011	0.1786	0.0274	0.0000	0.0000	0.2070	2,359	-9%
Comp. N	D			-21	-1	0	-1	-3			
	D·Mp	2,956	17%	-0.0002	-0.0893	0.0000	-0.0390	-0.0237	-0.1522	2,539	-2%
Average		2,531								2,580	

(a) For each comparable, D is the difference with the subject, and D·Mp is the difference multiplied by the marginal price; (b) Deviation from average, before adjustments; (c) Sum of the adjustments (in logarithms); (d) Adjusted unit price; (e) Deviation from the average, after adjustments.

Source: own study.

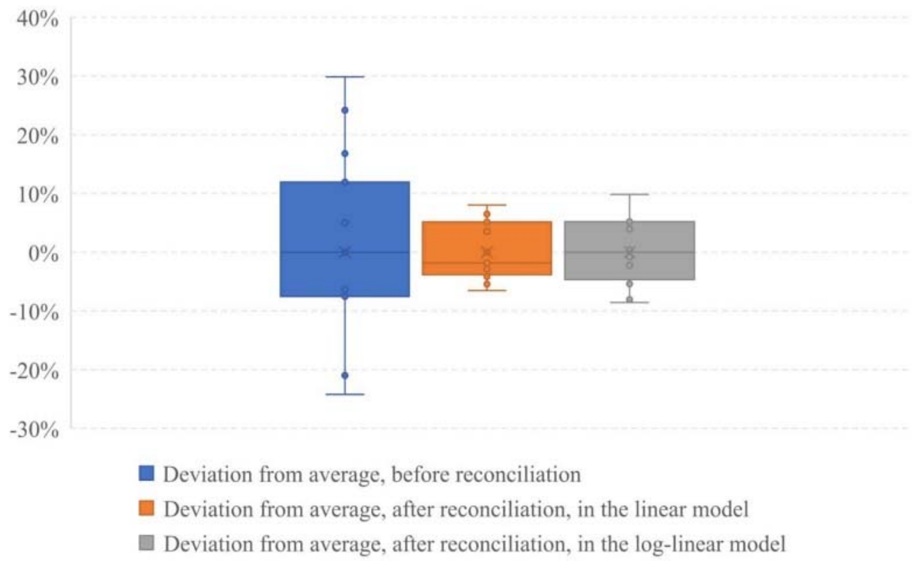

Fig. 6. Deviations from the average price per unit area. *Source*: own study.

It is worth noting that the percentage weights of the hybrid attributes found here should be properly interpreted as mere implicit prices instead of marginal prices, according to a distinction that has been recently put forward in the literature (Lisi, 2019). The positive influence exerted by the floor level on housing prices is in keeping with the findings presented in many hedonic studies (Wong et al., 2011; Xiao et al., 2019). The percentage weight found here is slightly higher than the one identified in other studies (Sun et al., 2005; Conroy et al., 2013), but it is very similar to the results of a recent analysis (Tajima, 2019). Notably, the penthouse dummy variable is not significant, which may be due to the fact that it becomes superfluous once the floor level is controlled for in the model (Conroy et al., 2013). The low statistical significance of the panoramic view and the limited role it plays in shaping housing values, up to some percentage points, are in keeping with the findings of earlier hedonic studies (Willis & Garrod, 1993; Tyrväinen & Miettinen, 2000; Song & Knaap, 2003) but are also in contrast with the results of other works, which found the price and rent premiums of attractive surroundings in the range of 19% to 57% (Thorsnes, 2002; Bourassa et al., 2004; Baranzini & Schaerer, 2011). Indeed, the literature shows highly variable price effects depending on the kind of view, environmental amenities involved, and distance (Bourassa et al., 2004; Sander & Polasky, 2009), as well as depending on the real estate cycle (Bourassa et al., 2005). Although several works show that consumers are usually concerned with building orientation (Wang & Li, 2004; Gao & Asami, 2011; Fadaei et al., 2015), a recent hedonic analysis (Huang et al., 2017) confirms the relatively low weight of the main orientation, as found here in the log-linear model. Nonetheless, the significant weight identified using the linear model is in keeping with the findings of two studies specifically focusing on building orientation (Lu, 2018; Song et al., 2019), where the premium for a south-facing orientation has been found to vary between 7.8% (in comparison to a west-facing orientation) and 17.9% (in comparison to a north-facing one).

The analysis above suffers some limitations which pave the way for further improvements to the research. In particular, the coding system adopted for the hybrid attributes implicitly assumes a linear relationship so that the marginal price is constant for each level of the characteristics. For instance, no matter regardless of whether the main exposition is north for one flat and north-west for another, or south-west for the former and south for the latter, there is no change in the estimated implicit price. Nevertheless, that may not reflect the actual price that market players are willing to pay if the value accorded to different expositions is governed by a nonlinear function. The same remark holds true for other hybrid attributes, such as the floor level and the panoramic view. The issue could be addressed by transforming each attribute into a set of binary variables, but a much broader dataset would be needed to that end.

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