The value of the energy retrofit in the Italian housing market: two case-studies compared

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Abstract: - The important role of the buildings energy issue, recognized by the current international policies, is confirmed by the strategies employed in different European countries to promote energy efficiency measures. With reference to two samples of residential properties recently sold in the two Italian cities of Bari (Southern Italy) and Bolzano (Northern Italy), located in different areas in terms of the socio-economic and climatic factors, in the present research an econometric analysis to verify the contribution of the energy performance on the residential selling prices is implemented. The proposed methodology and the results obtained constitute a useful support for both the Public Institutions, interested in testing the effectiveness of the energy policies already activated and planning the future incentives, and the private operators, who can appropriately perform their investment decisions by taking into account the increase in the market values expected by the energy retrofit initiatives.

Key-Words: - energy policy; housing energy-efficiency retrofit; property value; housing market; genetic algorithm.

1 Introduction

The issue of the energy efficiency of buildings has been characterized by a widespread debate at national and international level. The reasons are mainly linked to the climate changes, to the historical dependence of almost all nations on limited and non-renewable energy sources, to cultural and social developments that require more sustainable choices for the future.

The international policies on the energy savings, on the one hand, aim at reducing the greenhouse gas emissions in the environment, on the other hand, at a more conscious use of the renewable energy sources. The evident positive effects generated at the global level by the processes of buildings energy efficiency, in the recent decades, have led to a growing attention to the energetic issue.

Among the different economic sectors, the construction one consumes about 40% of the final primary gross energy of the European Union (EU), [1] thus constituting one of the fields from which the most important energy savings could be obtained.

The EU aims at achieving the goal of 20% of the energy efficiency improvement in the member countries by 2020, through tools for the regulation and the diffusion of the energy efficiency of buildings. In fact, at the European level, the percentage of buildings that are energetically inefficient is, on average, around 75% [1].

In Italy, over 60% of residential buildings ï overall more than 12 million, for a total of over 31 million residential units ï is characterized by the lowest Energy Performance Certification (EPC) label (ñGò), i.e. the least performing in terms of energy savings, and were built before the first law on energy saving [2, 3].

The strategic actions implemented in Italy in the building sector concern both the new construction projects and the energy retrofit initiatives of the existing building heritage [4, 5]. In the case of new properties, the energy laws aim at improving, during the projectual phase, the physical-technical choices, the materials and the technologies used, in the perspective of the principle of energy and economic sustainability of the projects to be realized.

In the case of existing buildings, the measures promoted aim at reducing the energy consumption, through the improvement of the thermal insulation of the buildings (e.g. the replacement of the windows frames), the installation of the thermal solar panels, the replacement of the winter air conditioning systems with the condensation boilers and the heat pumps.

In order to promote the energy efficiency of both existing and new buildings, in Italy several tax measures, which provide for the deduction of a part of the costs incurred for the energy improvement, have been promulgated. In particular, the 2017 Budget Law [6] introduced a tax deduction equal to 65% for costs incurred by the end of the reference year, in order to incentivize buildings energy efficiency initiatives and to make the collectivity more aware of a more conscious use of the resources.

The main Italian normative references in terms of building energy efficiency is contained in the Legislative Decree August 19, 2005, No. 192, aimed at promoting the improvement of the energy performance of properties and defining the minimum efficiency requirements [7].

The Strategy for the National Property Assets Requalification (STREPIN), in accordance with the Legislative Decree 2014, No. 102 [3], aims at obtaining energy savings by 2020 equal to 15.50 Mtoe through measures for the promotion of energy efficiency. In particular, it is provided that the construction sector will reach the annual amount of 4.90 Mtoe, divided in 3.67 Mtoe/year in the residential sector and 1.23 Mtoe/year in the non-residential sector [3].

Some Authors [8] highlight the overall national savings that can be achieved by adopting specific technical criteria on new and refurbished buildings. In particular, the energy savings have been estimated equal to 5.00 Mtoe/year in the period 2021-2030, compared to the maximum value of 9.00 Mtoe/year currently consumed.

The characteristics of each property in terms of energy consumption are expressed through the assignment of a score in a scale of ten labels, from the ñA4ò, which is the most performing ranking, to the ñGò, that constitutes the least performing one. The attribution of the appropriate EPC label of a building considers different technological factors, such as: the geometric peculiarities of the building, the building finishing materials, the window frames, the cooling and heating systems of the rooms, the hot water production, the presence of renewable energy production systems [9].

In recent years, several Authors have studied the relationships between the energy performance of the buildings and the respective selling prices [10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21]. The results obtained by the researches carried out in different countries, generally, have shown a direct influence of the energy performance on the property prices, although this relationship is functionally different in the various property markets analyzed [22].

2 Aim

Taking into account the framework outlined, the present research aims at studying and comparing, with reference to two Italian cities located in different territorial contexts, the market appreciation of the energy performance of residential units compared to their selling prices.

The results obtained may constitute a useful support: *i)* for the Public Institutions, in order to verify the effectiveness of the energy policies already activated, to plan future incentives based on the current demand of the local market, to promote energy efficiency initiatives through a more appropriate contextualization of the regulations to the peculiarities of the reference territory; *ii)* for the private operators (entrepreneurs, builders, real estate funds, etc.), in order to appropriately perform their investment decisions by considering the "energy" demand in the specific market and, consequently, the potential revenues, in terms of increasing market values, that could be reasonably achievable through the energy retrofit actions.

The two Italian cities analyzed are located in geographical areas characterized by different climatic and socio-economic factors: the city of Bari

(Southern Italy), overlooking the Adriatic sea, in a geographical context affected by a mild and sufficiently ventilated climate; the city of Bolzano (Northern Italy), in an internal area and on a hill, affected by frigid temperatures in winter and cool in the warmer seasons.

For both the case studies, through an econometric analysis, the relationships between the residential selling prices and the main market variables are identified, by verifying the empirical consistency of the results and clarifying the contribution of the energetic performance on the housing prices. The results obtained in the two cases are then compared.

The paper is structured as follows. Section 3 presents the two case studies: the socio-economic and climatic parameters are contextualized; the explanatory variables considered in the econometric model are identified, based on the market preferences detected in the two cities; the main descriptive statistics of the two detected samples are illustrated. Section 4 outlines the method used and its applications to the two study samples are implemented; the main results in terms of statistical significance of the equations obtained and empirical reliability of the functional relationships are reported and the outputs for the two cities are compared. Finally, in section 5 the conclusions of the work are discussed.

3 Case studies: socio-economic and climatic characterization

The two cities in analysis are located in different contexts in terms of socio-economic and meteorological conditions.

The city of Bari is the main city of the Apulia region, in Southern Italy. It covers an area of about 120 km^2, with a population just over 325,000 inhabitants. The average annual per capita income is about ú 13,500.

The city of Bolzano, is located in the Trentino Alto-Adige region, in Northern Italy. It is characterized by a total population of about 110,000 inhabitants and a territorial extension of 50 Km^2. The average annual per capita income is around ú 20,000.

A factor that could influence the effect of the energy component on the market values in the two selected cities concerns the specific meteorological conditions. The city of Bari is characterized by a Mediterranean climate, with moderate temperature variation, due to the mitigating effects of the sea. The annual average temperatures recorded from 1981 to 2017 range between 15.0 and 17.5 Celsius degrees, with average minimum temperatures between 10.0 and 13.0 Celsius degrees. The average annual maximum temperatures vary between 19.8 and 22.5 Celsius degrees [23].

The city of Bolzano, for its position in an Alpine valley floor, is affected by a continental climate, with high temperature variations between summer and winter seasons. The average annual temperatures, recorded in the last thirty-six years, range from 11.0 to 14.0 Celsius degrees; the minimum temperatures vary between 4.0 and 9.0 Celsius degrees, the maximum temperatures range from 16.5 to 20.3 Celsius degrees [24].

3.1 The variables of the models

For each of the two cities considered, a sample of two hundred residential properties, sold in the period 2016-2017, has been collected.

For each residential unit, the selling price and the influencing factors that, on the basis of the indications provided by the local real estate agents, are considered by the buyers and the sellers in the negotiation phase, have been detected.

With reference to the model, the dependent variable is the unit selling price (Y). In this regard, the analysis of the samples has shown an average value of the unit price equal to ú/m^2 2,244 for the city of Bari and ú/m^2 3,627 for the city of Bolzano.

The explanatory variables considered and the relative descriptive statistics are described below.

Intrinsic characteristics:

Å the *total surface* of the property, expressed in square meters of gross floor area [S]. The average value for the sample measured in Bari is 100 m^2, whereas for Bolzano it is around 90 m^2;

Å the *number of the bathrooms* in the property [B]. In both the cases, the highest frequency concerns properties with only one bathroom (55% of the sample for the city of Bari and 78% for the city of Bolzano). In the city of Bari about 3% of the sample has three bathrooms, whereas this situation is never verified for the city of Bolzano;

Å the *floor* level on which the property is located [F]. In both the samples, the majority of the apartments is located on the first floor (33% for the city of Bari and 51% for the city of Bolzano);

Å the *presence of the lift* [L]. In the model this variable is considered as a dummy variable, in particular the presence of this service is represented by the value "1", whereas the absence is indicated with the value "0". For both the samples this factor frequently occurs: about

70% of the residential units in the city of Bari and about 80% of the properties of the Bolzano sample are characterized by the presence of the lift;

Å the *presence of the parking* [C]. In the model this variable is interpreted as a dummy variable, in particular the value "0" indicates the absence of the parking space, whereas the value "1" denotes its presence. In both the samples analyzed, about half of the properties has a parking (45% and 55% respectively in the samples of the cities of Bari and Bolzano);

Å the *quality of the maintenance conditions*, taken as a qualitative variable and differentiated, through a synthetic evaluation, by the ñto be restructuredò [Mp], ñgoodò [Mg] and ñexcellentò [Me] categories. In the model, for this explanatory variable, the dummy logic has been considered: the score "1" is assigned to the specific category of the maintenance conditions of each property and the score "0" to the other two. In particular: the "to be restructured" qualification [Mp] concerns properties that require refurbishment interventions for their functionality; the "good" state [Mg] refers to habitable apartments; the "excellent" state [Me] indicates properties that are characterized by high constructive and aesthetic qualities, recently renovated and whose conservative state denotes optimum finishing levels. With reference to the Bari sample, about 50% of the properties analyzed is characterized by a "to be restructured" state, 30% by a ñgoodò state and 20% by ñexcellentò maintenance conditions. In the sample of the city of Bolzano, 45% of the properties presents an ñexcellentò state of maintenance, 35% a ñgoodò state and 20% a ñto be restructuredò state;

Å the *age of the building* in which the residential unit is located [Y]. This variable is calculated as the difference between the selling year and the year of construction of the building. The average value recorded for the sample of the city of Bari is approximately 42 years, whereas it is around 35 years for the sample of the city of Bolzano;

Å the *EPC label*, expressed, according with the current regulations, through the denominations from ñA4ò (the highest level) to ñGò (the lowest level). In the present research, the EPC labels from ñA4ò to ñAò are gather into a single explanatory variable (EpA). Therefore, the variables considered are specified by the following abbreviations, which recall the label they belong to: EpA, EpB, EpC, EpD, EpE, EpF, EpG. Each parameter is interpreted as a dummy variable, assigning a score equal to "1" to the EPC label of the property and, consequently, the score equal to "0" to all the others. Most of the properties of the two study cities are characterized by the least performing energy label: respectively 30% of the residential units in the city of Bari and 38% for the city of Bolzano are characterized by G EPC-label. Remaining percentages are equally distributed in the other EPC labels: in particular, the highest performing energy label ("A") concerns 15% of the sample of the city of Bari and 12% of the city of Bolzano.

Locational characteristics:

Å the *distance from the nearest motorway*, expressed in kilometers it takes to get there by car [T]. The average values measured for the two samples are about 3.0 km for the city of Bari and about 4.5 km for the city of Bolzano;

Å the *distance from the nearest subway*, expressed in kilometers it takes to walk to it [W]. This variable characterizes exclusively the properties of the sample of the city of Bari (average distance measured equal to about 3.0 km), as the metropolitan public transport system is absent in the city of Bolzano;

Å the *trade area* in which the property is located, considering the geographical distribution developed by the Observatory of the Real Estate Market of the Italian Revenue Agency. This factor is considered following the logic of dummy variables and, in particular, the trade areas considered are four: "central", "semi-central", "peripheral" and "suburban". For each property, the score "1" is assigned to the zone in which the property is located, and the score "0" is reported for all the remaining trade areas in which the municipal territory is divided. The location of the residential units for the two samples analyzed is different: in the case of Bari, about 50% of the properties belongs to the "central" trade area, 20% to the ñsemi-centralò trade area, 10% to the ñperipheralò zone and, finally, 20% are in a ñsuburbanò area, whereas in the case of the sample of the city of Bolzano about 38% of the properties are in a "central" position, 37% are located in the "semi-central" area, 25% in the "peripheral" area.

4 The method

The method implemented is the *Evolutionary Polynomial Regression*, a hybrid data-driven technique that implements a simple genetic algorithm engine, in order to combine numerical and symbolic regression methods using polynomial structures [25].

The methodology is a versatile symbolic regression tool based on experimental data and it can be considered as a generalization of the stepwise regression, that is linear with respect to regression parameters, but it is non-linear in the model structures.

The generic expression is given by the Eq. (1):

$$Y = a_0 + \sum_{i=1}^{n} [a_i \cdot (X_1)^{(i,1)} \cdot \ldots \cdot (X_j)^{(i,j)} \cdot f((X_1)^{(i,j+1)} \cdot \ldots \cdot (X_j)^{(i,2j)})] \quad (1)$$

where *n* is the number of additive terms, i.e. the length of the polynomial expression (bias excluded), a_i are the numerical parameters to be valued, X_i are candidate explanatory variables, *(i, l)* - with *l = (1, ..., 2j)* - is the exponent of the *l-th* input within the *i-th* term in the Eq. (1), *f* is a function constructed by the process. In particular, the function *f* is selected by the user among a set of possible mathematical expressions generated by the underlying algorithm, the exponents *(i, l)* are also chosen by the user from a set of candidate values (real numbers) in the preliminary phase and the parameters of the function are evaluated through a Least Squares method.

The quantity and complexity of the solutions that the methodology can generate depend on the number of maximum terms and the possible exponents that the user defines in the preliminary phase. The accuracy of each equation returned is checked through its Coefficient of Determination (COD) [26, 27].

As known, the model performance is higher when the COD is close to the unit value. Another potentiality of the methodology is the ability to simultaneously pursue different objective functions. In this sense, it is possible to define an optimal Pareto frontier of the prefixed objectives (Fig. 1), usually conflictual, and aimed at:

i) the maximization of the model accuracy, through the satisfaction of appropriate statistical criteria for the verification of the equation;

ii) the maximization of the modelôs parsimony, through the minimization of the number of terms (a_i) of the equation;

iii) the reduction of the complexity of the model, through the minimization of the number of the explanatory variables (*Xi*) of the final equation.

In this way, a range of models is offered to the operator, among which it is possible to choose the most appropriate solution according to the specific needs, the knowledge of the phenomenon in analysis and the type of experimental data used.

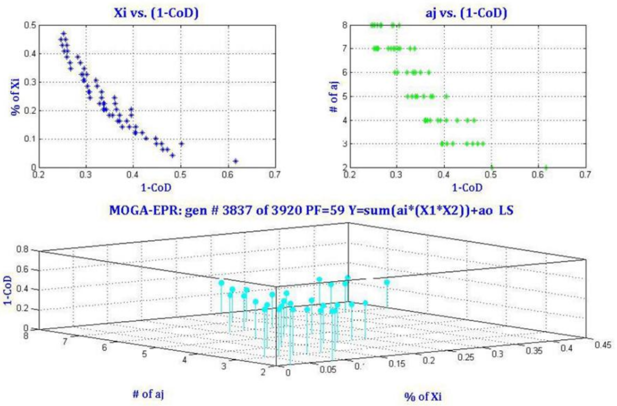

Fig.1. *Evolutionary Polynomial Regression* elaboration for the definition of the Pareto frontier

4.1 Results of the model application

The model has been implemented for both the case studies considering the structure of the basic model identified in Eq. (1). Each generated algebraic expression consists of a maximum number of eight terms where, in particular, each term is the combination of the selected explanatory variables, raised to the appropriate numerical exponents.

For both the case studies, the defined exponents are eleven (-3, -2, 1.5, -1, -0.5, 0, 0.5, 1, 1.5, 2, 3), in order to generate a wide range of solutions among which the "best" one in terms of statistical accuracy and simplicity of the relationship between the dependent variable and the explanatory variables will be selected.

In accordance with the mathematical formulations generally found in the current literature [28, 29], the log-linear model has been used: the empirical evidence shows that explaining unit prices improves the fit of the model [30].

4.1.1 The model for the city of Bari

The analysis carried out on the sample of the city of Bari has generated several models. Among these, the Eq. (2) constitutes the best model in terms of statistical performance (COD) and mathematical simplicity.

$$\ln(P) = -0.30713 \cdot Ep_G^{0.5} + 0.24637 \cdot Ep_A^{0.5} + 0.22598 \cdot Me + 0.5608 \cdot L^{0.5} + \\ -0.024144 \cdot S^{0.5} \cdot L^{0.5} \cdot W^{0.5} - 0.000087575 \cdot S^2 \cdot Mp^{0.5} \cdot Usb + 7.4529 \quad (2)$$

The model is defined by an algebraic expression consisting of seven additive terms. The COD, equal to 71.3%, shows a good statistical reliability of the model.

The variables selected by the methodology, i.e. the factors that mostly influence the housing prices, are: the *lowest performing EPC label* (EpG), the *highest performing EPC label* (EpA), the ñ*excellent*ò *maintenance conditions* (Me), the *presence of the lift* (L), the *total surface* of the property (S), the *distance from the nearest subway* (W), the ñ*to be restructured*ò *maintenance conditions* (Mp), the *location of the property in a suburban area* (Usb). Among the characteristics selected by the model, the factors related to the *highest performing EPC label* (EpA) and the *lowest performing label* (EpG) and to the *"excellent" maintenance conditions* (Me) have an ñindividualò explanatory capacity, being the only variables of the respective monomials; instead, the other variables are combined in the related terms of the Eq. (2).

For the individual variables (EpA, EpG, Me) the empirical reliability is verified by the signs of the coefficients: in particular, the model shows a direct correlation between the housing prices and, respectively, the *highest performing EPC label* (EpA) and the ñ*excellent*ò *maintenance conditions* of the property (Me), whereas an inverse proportionality between the unit selling prices and the *lowest performing EPC label* (EpG) is observed.

The verification of the empirical evidence for the ñcombinedò variables is less immediate. In these cases, the mathematical expression of the Eq. (2) does not allow to immediately check the empirical reliability of the signs that precede the independent variables with the real phenomena observed.

In order to make explicit the contribution of these characteristics, for both the samples - Bari and Bolzano - the functional relationship of the *i-th* independent variable with the variation of the selling prices has been explained through an empiric approach that, instead of determining the partial derivative of the dependent variable with respect to the *i-th* variable, considers *i)* for the quantitative *j-th* variable, its average value of the starting database, *ii)* for the *k-th* dummy variable, the score "1" only for a single qualification provided among the categories considered.

Therefore, the analysis of the changes in value of the estimated variations of the selling prices in correspondence of each *i-th* variable in the range of its corresponding sample values is developed.

Through the empirical approach described, the functional relationships, represented in Figs. 2 and 3, between the explanatory variables selected by the Eq. (2) and the housing selling prices, are obtained. The graphs confirm the expected empirical relationships.

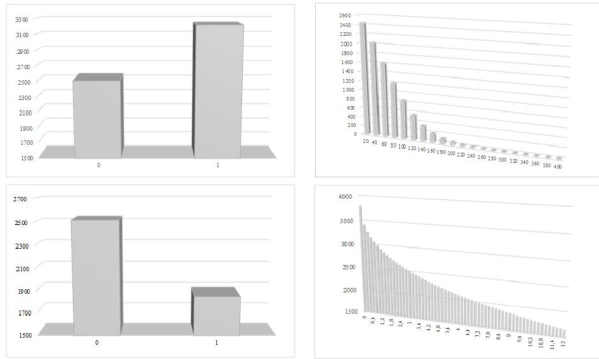

Fig. 2. Functional relationship between the selling prices and, respectively, the EPC-A label (top left), the total surface of the property (top right), the EPC-G label (down left) and the distance from the nearest subway (down right) for the sample of the city of Bari

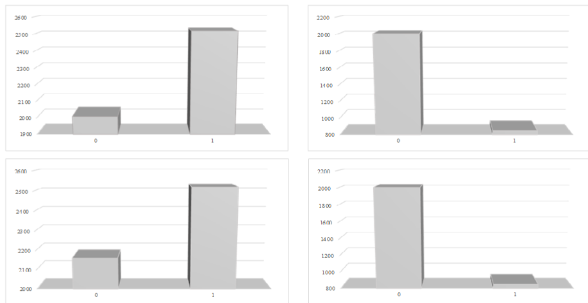

Fig. 3. Functional relationship between the selling prices and, respectively, the "excellent" maintenance conditions (top left), the ñto be restructuredò maintenance conditions (top right), the presence of the lift (down left) and the location of the property in a "suburban" location (down right) for the sample of the city of Bari

4.1.2 The model for Bolzano

The analysis carried out for the sample of the city of Bolzano has generated, as a model with the best compromise between the statistical accuracy (COD) and the reliability of the outputs, the model described by the Eq. (3).

$$ln(P) = -0.20542 \cdot Ep_G + 0.0059622 \cdot Me \cdot T^2 - 0.35153 \cdot Mg^{0.5} \cdot Ep_F + 0.020997 \cdot L^{0.5} \cdot Ep_A \cdot Y^{0.5} + 0.10269 \cdot B \cdot F^{0.5} \cdot Uc^{0.5} - 0.045061 \cdot S^{0.5} + 0.02603 \cdot S^{0.5} \cdot Ep_A + 8.5596 \quad (3)$$

The model consists of a mathematical expression of eight additive terms. The COD is equal to 75.4%, which denotes a good statistical reliability of the obtained relationships.

The implementation of the *Evolutionary Polynomial Regression* method has allowed the selection of the following variables, as the most influential ones in the process of the property price formation: the *lowest performing EPC label* (EpG), the ***ñ**excellent**ò** maintenance conditions* (Me), the *distance from the nearest motorway* (T), the ***ñ**good**ò** maintenance conditions* (Mg), the ***ñ**F**ò** EPC label* (EpF), the *presence of the lift* (L), the *highest performing EPC label* (EpA), the *age of the building* in which the residential property is located (Y), the *number of bathrooms* (B), the *floor level* (F), the *location of the building in the **ñ**central**ò** area* (Uc) and the *total surface* of the residential unit (S).

The empirical coherence of the signs of the coefficients for the characteristic the *lowest performing EPC label* (EpG), that is the only factor that appears in the Eq. (3) as an individual variable, is immediately verified: for this variable, the negative sign that precedes the term in which it appears, attests the inverse proportionality with the residential selling prices of the sample.

The functional relationships between the combined variables and the housing prices are obtained through the logical-empirical approach already illustrated in paragraph 4.2.1. Figs. 4, 5 and 6 confirm the empirical reliability of the functional relationships between the explanatory variables selected by Eq. (3) and the residential selling prices.

In particular, the direct functional relationship between the *floor level* characteristic (F) and the property prices is easily understandable, due to the composition of the sample analyzed for the city of Bolzano, whose 80% is characterized by the presence of the lift (L).

For the variable the *age of the building* in which the residential unit is located (Y), the direct correlation with housing prices can be deduced by observing that, in the analysis carried out by the empirical approach described, this variable expresses its influence on the selling prices exclusively for technologically efficient properties ï i.e. equipped with a *lift* (L=1) and characterized by the *highest performing EPC label* (EpA=1) -, for which the high "historical" value of the building leads to a significant increase in the property prices.

Finally, the analysis shows a direct relationship between the variable *distance from the nearest motorway* (T) and the selling prices: this functional relationship depends on the higher appreciation of the residential market for apartments characterized by lower noise pollution.

The graphs relating to the other variables selected by the model of the Eq. (3) are easily interpretable and coherent with the real phenomena observed.

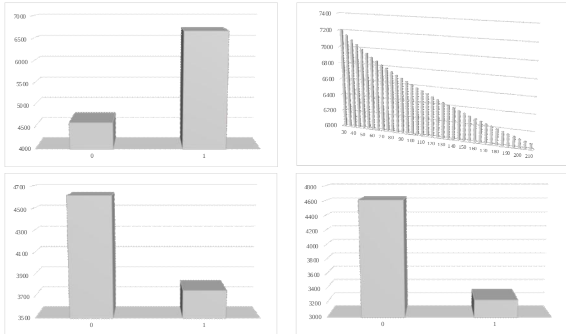

Fig. 4. Functional relationship between the selling prices and, respectively, the EPC-A label (top left), the total surface of the property (top right), the EPC-G label (down left) and the EPC-F label (down right) for the sample of the city of Bolzano

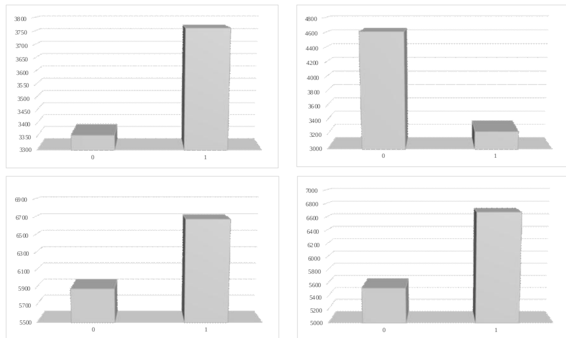

Fig. 5. Functional relationship between the selling prices and, respectively, the "excellent" maintenance conditions (top left), the "good" maintenance conditions (top right), the lift presence (down left) and the "central" location (down right) for the sample of the city of Bolzano

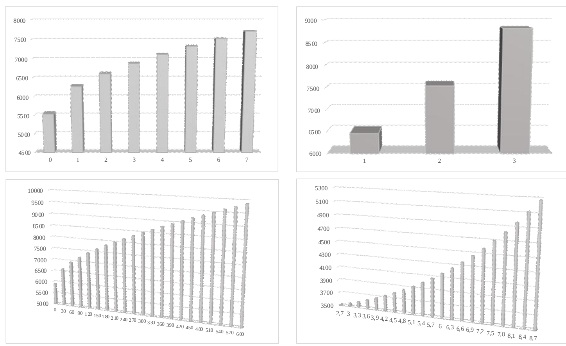

Fig. 6. Functional relationship between the selling prices and, respectively, the floor level (top left), the number of bathrooms (top right), the age of the building (down left) and the distance from the nearest motorway (down right) for the sample of the city of Bolzano

4.2 Comparison of the outputs for the two case studies

The main results obtained for the two models of the city samples of Bari and Bolzano have been analyzed and compared. Fig. 7 shows the percentage variations - in absolute terms - of the selling prices, generated by the dummy variables selected by both the models (EpG, EpA, L, Me).

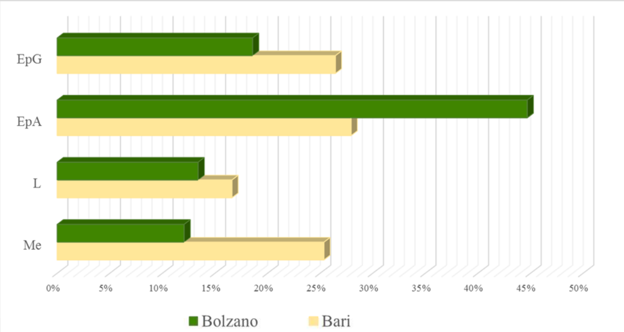

Fig. 7. Comparison between the percentage contributions, on the selling prices, of the dummy variables selected by both the models obtained for the two case studies

First of all, regards the energy components, it should be noted that the contribution of the *"A" EPC label* (EpA) is higher for the case study of Bolzano than for the sample of Bari: in the first case, the percentage variation in property prices due to the *"A" EPC label* is around 45%, whereas, in the second case, it is about 30%. However, it should be highlighted that, following the empirical approach employed and on the basis of the expression of Eq. (3), the contribution of the *"A" EPC label* for the sample of Bolzano occurs in the situation in which the property has a *lift* (L=1) and is characterized by the average values for the *surface* (S) and the *age of the building* in which the flat is located (Y) respectively equal to 90 m^2 and 35 years. The significant weight of the ***ñ**A**ò*** *EPC label* on the phenomena of the selling price formation in the model obtained for the city of Bolzano, is related to the specific climatic and socio-economic conditions of the city (high temperature variations between summer and winter seasons, widespread wealth of the population, high attention of the community to the environmental sustainability issue).

The *lowest performing EPC label* (EpG) is characterized by a higher percentage marginal contribution on the selling prices for the sample of the city of Bari (-27%) compared to the case study of the city of Bolzano (-19%). However, it should be noted that the model for the city of Bari identifies only the "extreme" energy labels (EpA and EpG) as the most influential ones on the housing prices, whereas the model obtained for the city of Bolzano, in addition to the significant contribution of the ***ñ**A**ò*** *EPC label*, shows a market depreciation related to the two worst *EPC label*, i.e. *"F"* - characterized by a marginal percentage contribution on property prices equal to about -30% - and *"G":* in the case of the city of Bolzano, therefore, the reductive effect of the housing prices connected to low energy performances is distributed between these two EPC labels.

The percentage variation in property prices generated by the *presence of the lift* (L) is similar in the two samples studied, equal to about 13% for the city sample of Bolzano and about 17% for the city sample of Bari. However, in the case of the city of Bolzano, the selling prices are affected by this characteristic only in the situation of properties built according to high energy sustainability performance (EPA=1), whereas in the case of the city of Bari the *presence of the lift* (L) constitutes an individual variable in the selected model.

Finally, the models obtained for the two case studies consider the characteristic ñ*excellent***ò** *maintenance condition* (Me). This variable mostly weighs in the model for the city of Bari (25%) compared to the case study of the city of Bolzano (12%). This situation highlights the preference of the buyers of the city of Bolzano for the energetic components of the buildings compared to high historical-architectural property qualities and outstanding finishing qualities.

5 Conclusions

In the context of the current national and international policies, the significant role of the building energy consumption issue is confirmed by the different strategies carried out to promote energy efficiency measures.

With reference to two samples of two hundred residential properties recently sold, located in different geographical, climatic and socio-economic Italian areas, an econometric analysis has been implemented, in order to analyze the marginal contribution of the energy performance factors on the housing prices and to compare the results.

The models obtained show that, in both the case studies, the energy components contribute to the property price formation, but the market appreciation is different. The analyzes carried out outline a higher effect of the energy components on the housing prices for the case study of the city of Bolzano, for which the optimum energy characteristic (*"A" EPC label*) can lead to an increase in property prices equal to about 45%, whereas the marginal contribution of the same factor for the sample of the city of Bari is equal to 30%.

The results of the research highlight the opportunity of a territorial characterization of the housing energy retrofit values, as a support *i)* for the Public Institutions, engaged in the definition of regulations aimed at promoting the energy saving initiatives in the construction sector and that are able to effectively satisfy the reference market demand, *ii)* for the private operators (investors, builders, real estate funds, etc.), which will be able to manage their investment decisions in the building energy sustainability through an appropriate assessment of the increases in property values determined by the regeneration initiatives to be realized.

Further insights may concern the application of the methodology proposed in other national and international territorial contexts, in order to analyze the contributions of the energy performances on the housing selling prices in different property markets.

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