The Contribution of the Most Influencing Factors on the Housing Rents: An Analysis in the City of Milan (Italy)

Pierluigi Morano[1], Francesco Tajani[2], Felicia Di Liddo[1], Rossana Ranieri[2(✉)], and Paola Amoruso[3]

[1] Department of Civil, Environmental, Land, Building Engineering and Chemistry, Polytechnic University of Bari, 70125 Bari, Italy

[2] Department of Architecture and Design, "Sapienza" University of Rome, 00196 Rome, Italy
rossana.ranieri@uniroma1.it

[3] Department of Economics and Management, LUM Giuseppe Degennaro University, 70010 Casamassima, BA, Italy

Abstract. With reference to a study sample related to the city of Milan (Northern Italy), the present research intends to identify the impact of the most influencing factors on the residential rents. In particular, in the analysis two hundred and twenty housing properties rented in the second half of 2019 have been collected and the most relevant intrinsic and extrinsic factors in the bargaining phases between the lessors and the potential lessees have been selected. Through the implementation of an econometric technique the investigation of the different functional relationships between the explanatory factors considered and the housing rents has been carried out. The present research could represent a valid reference for the private operators in the investment decisions phases and for the Public Administrations to monitor housing rent dynamics and to provide essential implications for fair housing policies.

Keywords: Rental market · Residential rents · Evolutionary Polynomial Regression · Influencing factors

1 Introduction

In the last years, the housing rental market has been changed. With reference to the previous period to the Covid-19, the demand for rental housing had considerably increased: from 2011 to 2018, in fact, the number of new rental contracts has grown of +18% [25]. Moreover, in addition to the traditional contractual forms, the short-term residential segment has been spread especially in touristic cities and in the urban areas near to the most important historical buildings and/or in the university neighborhoods.

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Currently, the rental market has a significant dimension: in 2018 the Bank of Italy has reported that about the 20% of the Italian families in 2016 lived in a rented house, whose 38% concerned the youngest people and 46% the poorest community groups [1]. In the first semester of 2020, in the Italian context the number of people that has rented a residential property has increased by 3.3% (74.7% compared to the number of lessees detected in the same period of 2019, when the percentage was 71.4%). In particular, the "classical" residential rental demand represents the 54% of the total housing one and it has increased by +7.8% compared to the 2019, mostly due to the lowered rental values [28].

In the current situation, the spread of COVID-19 pandemic has been determining significant effects on the residential rental market. The use of distance learning and smart working has led many non-resident students (14.8% of the total rental demand, declining by 3.2%) and workers (29.5% of the total rental demand, declining by 3.7%) to leave their rented houses, generating a greater market supply and a lower demand [4].

The greater market supply – mainly related to the return of students and workers to the original houses and to the lower demand of short-term rental for the possibility to journey exclusively for needs related to work or health – has involved the decrease in rental prices equal approximately to −7.5% (−8.0% for the two-room and three-room apartments, −7.2% for four-room apartments). The decrease in residential rents is different according to the geographic context: in the biggest Italian cities a strong reduction has been pointed out (−9.5%), whereas in small and medium-sized cities a lower decrease has been noted (−3.8%) [14].

The variation on the Italian average rents - from 616€/flat in 2019 to 570€/flat in 2020 - determines a return to those charged in 2016 [25]: this situation confirms the higher flexibility of the housing rental market, differently from the stricter residential sales market for which a lower variation in prices has been found.

Finally, in the framework outlined, also for the phenomenon related to the "apartament share" – that represents the 11.6% of the total rental demand – a negative trend has been detected, equal to −2.4% compared to the 2019.

The higher supply related to residential properties is allowing the potential lessees to find the "desired" property, by observing a trend to look for bigger houses with external spaces. In this sense, a variation in rental market demand is expected.

The analysis of the most influencing factors on housing rents has a significant impact for the sustainable urban planning and management: several Authors have highlighted the greater preference of potential housing buyers or homeowners for urban areas in which a high life qualify level is perceived, e.g. characterized by a good accessibility to the green spaces, with healthy air and without acoustic pollution [6, 7, 11, 29]. Other researches have identified the most influencing factors on residential rents, in order to quantify the importance of the physical characteristics in the rental market dynamics [8, 12, 23, 26, 31].

2 Aim

The present analysis concerns the topic outlined. The wok intends to analyze the effects of the most influencing factors on housing rents. With reference to the Italian city of Milan, the paper aims to investigate the functional relationships of residential rents with the main intrinsic and extrinsic characteristics considered by the housing lessors and the potential lessees in the bargaining phases. The analysis is carried out by considering a study sample of two hundred and twenty housing properties rented in the second half of 2019 and located in the city of Milan. The implementation of an econometric technique on the collected sample allows to point out the most significant factors in the rents formation processes and to examine the different functional relationships between the explanatory variables considered and the housing rents.

The results obtained may be a reference for the private owners of properties and investors to identify the most relevant intrinsic and extrinsic factors for potential lessees and, eventually, to adapt the property characteristics according to the tenant requests and to activate renovation interventions able to increase the market rental value. From the Public Administration point of view, the outputs could be used to monitor the housing rent dynamics and to provide essential implications to reach fair housing goals [5].

Furthermore, the paper represents the first step of a wider research focalized on the analysis of housing rental market. In this sense, the work concerns the identification of the most influencing factors on rental values in the ante-Covid period (second half of 2019). The results obtained could be compared with those deriving from the same analysis to be carried out with reference to the post-Covid period, in order to assess likely variations in the rental demand in terms of the most influencing factors considered by potential lessees.

The paper is structured as follows. In Sect. 3 (“Case study”) the sample collected and the variables considered have been described. In Sect. 4 (“Method”) the econometric technique has been illustrated. In Sect. 5 (“Application of the method to the case study”) the interpretation of the results obtained by the implementation of the econometric technique in terms of functional relationships between the explanatory variables considered and the residential rents has been explained. Finally in Sect. 6 (“Conclusions”) the findings of the work have been reported.

3 Case Study

With reference to the city of Milan (Northern Italy), a sample of two hundred and twenty residential properties, rented in the second half of 2019, has been collected.

In Fig. 1 the localization of the properties is shown.

It should be observed that the residential units selected are distributed in the three urban areas (central, semi-central, peripheral) of the city of Milan.



Fig. 1. Localization of the sample of two hundred and twenty residential properties in the city of Milan

3.1 Variables

For each property of the study sample, the rent (dependent variable) and the most influencing intrinsic and extrinsic factors (independent variables) have been detected. As confirmed by the reference local market operators (real estate agents and experts), the factors identified for the analysis represent the main characteristics considered by lessors and lessees in the phases of residential properties negotiation. The two main categories of independent variables are illustrated below.

Intrinsic variables:

- the internal floor surface [Si], expressed in square meters of gross floor area of the property;
- the surface of private external space, i.e. gardens, green areas, courtyards [Sg], expressed in square meters of gross floor area;
- the surface of balcony, terraces and patios [Sb], expressed in square meters of gross floor area;
- the presence of external private condominium areas [Se], assessed as a dummy variables in which the value "zero" indicates the absence of this space, whereas the value "one" indicates the presence;
- the floor on which the property is located [F];
- the number of bathrooms in the property [B];
- the presence of kitchen located in the same living room of the property [K], assessed as a dummy variable for which the value "one" verifies this situation, whereas the value "zero" indicates that the kitchen and the living room are in two different home spaces separated by internal walls and doors.
- the quality of the property maintenance conditions, considered as a qualitative variable and differentiated, through a synthetic evaluation, by the categories "to be restructured" [Mb], "good" [Mg] and "excellent" [Me] as a dummy variable. In particular, for the definition of the quality of the maintenance conditions, the assessment has been carried out by comparing the information obtained from the real estate agents

consulted, surveys carried out by web and on site, i.e. through digital photographs or user comments. Each of the three categories that summarize the three possible states of maintenance denotes different quality and conditions. The "to be restructured" condition (Mp) indicates residential properties for which substantial restructuring interventions are necessary as the conservative state strongly bad, the "good" state (Mg) indicates houses that are immediately usable and in which the maintenance conditions are acceptable, whereas the "excellent" state (Me) refers to properties characterized by high aesthetic and structural values with valuable trimmings and architectural qualities.

- the EPC label, expressed, according with the current regulations, through the denominations from A4 (the highest level) to G (the lowest level). In the present research, the EPC labels from A4 to B are gather into a single explanatory variable [E_ab] and the EPC labels from C to E are gather into a single explanatory variable [E_cde], whereas the EPC labels F and G are not included among the variables selected. The variable is interpreted as a dummy variable, assigning a score equal to "one" to the EPC label of the property and, consequently, the score equal to "zero" to all the others. It is evident that if the property EPC level is F or G both the variables E_ab and E:cde are equal to "zero" score;
- the age of the building in which the residential unit is located [Yc]. This variable is calculated as the difference between the year 2019 and the year of construction of the building.

Extrinsic variables:

- the distance from the nearest subway [Dm], expressed in kilometers it takes to walk to it;
- the distance from the central train station [Ds], expressed in kilometers it takes to walk to it;
- the distance from the nearest university centre [Du], expressed in kilometers it takes to walk to it;
- the distance from the central pole [Dp] of the city, expressed in km it takes to walk to it. In the analysis related to the city of Milan, the central pole is defined as a religious and historical monument located in the centre of the city from which the main arteria roads leading off. In particular, the "Duomo" has been considered;
- the distance from the nearest urban green space [Dg], expressed in km it takes to walk to it;
- the municipal trade area in which the property is located, considering the geographical distribution developed by the Italian Revenue Agency [24], because of the different location characteristics that contribute to the formation of the rental prices. In particular, three trade areas are included in the analysis among those defined by the Italian Revenue Agency: "central" [C], "semi-central" [Sc], "peripheral" [P]. For each property, the score "one" is assigned if the property belong to the specific trade area, whereas the score "zero" is reported for all the remaining locational factors. For the properties located in the suburban area all the variables C, Sc and P are equal to "zero".

4 Method

The econometric technique applied in the present research is the Evolutionary Polynomial Regression (EPR) which integrates the best features of numerical regression [10] with genetic programming [17]. Starting from experimental data, the technique searches for possible models in polynomial form in which each term that appears is composed of the combinations, with a different degree of complexity, of the explanatory variables selected by the user.

A more detailed illustration related to the EPR features and to the advantages of the technique implementation can be found in several contributions of the reference literature [9, 13, 21, 22, 27]. It should be highlighted that the EPR technique has never been implemented for the analysis of the influence of the most influencing factors on the rents. In this sense, the work represent the first applications of the EPR to the rental market sector.

In the present research, a general description about the main aspects of the technique implemented has been illustrated.

To determine the relationship Y = f (Xi), i.e. the price function able to define the functional relationships about the explanatory factors and the property prices, known the dependent variable (Y) and the independent variables (Xi), the generic expression of the non-linear model implemented in EPR is shown in Eq. (1):

$$Y = \sum_{i-n}^{l} \left[a_i \cdot (X_n)^{(i,n)} \ldots (X_j)^{(i,j)} \cdot f\left((X_n)^{(i,j+n)} \ldots (X_j)^{(i,2j)}\right) \right] + a_0 \tag{1}$$

where a_0 is the constant additive term, n is the number of additive terms, i.e., the length of the polynomial expression (constant additive term excluded), a_i represents the numerical parameter to be assessed for each additive term, X_i is the candidate explanatory variables to be selected by the model, (i, l) - with l = (1,…, 2j) - is the exponent of the *l*-th variable within the i-th additive term, f is a function selected by the user from a set of candidate mathematical expression. The exponents (i, l) are also chosen by the user from a range of candidate real numbers.

The main advantage related to the EPR implementation concerns the ability to simultaneously pursue different objective functions, such as to define an optimal Pareto frontier of the fixed conflictual objectives, that aim at *i)* the maximization of the model accuracy, through the satisfaction of appropriate statistical indicators; *ii)* the maximization of the model parsimony, through the minimization of the number of coefficients (ai) of the equation; *iii)* the reduction of the complexity of the model, through the minimization of the number of explanatory variables (Xi) of the final equation.

In this sense, the application of the econometric technique allows to generate several models characterized by a different statistical accuracy and mathematical structure complexity. In particular, the indicator of the statistical performance is the Coefficient of Determination (CoD), defined in Eq. (2):

$$CoD = 1 - \frac{N-1}{N} \cdot \frac{\sum\limits_{N} (y_e - y_d)^2}{\sum\limits_{N} (y_d - mean(y_d))^2} \tag{2}$$

where y_e are the values of the dependent variable assessed by the EPR method ($y_{\text{estimated}}$), y_d are the collected values of the dependent variable (y_{detected}), N is the sample size. The statistic reliability of each model is greater when the CoD is close to the unit value.

5 Application of the Method to the Case Study

With reference to the case study, the EPR technique has been implemented, taking into account the structure of the basic model identified in Eq. (1) without function f selected.

According to the results obtained in several studies [19], the dependent variable Pr (rental price) has been considered in logarithmic form (Y = ln(Pr)).

Furthermore, each price function generated consists of a maximum number of eight terms and each term is the combination of the selected explanatory variables, raised to the appropriate numerical exponents belong to the set (0; 0.5; 1; 2), in order to obtain a wide range of solutions.

The application of the EPR technique has generated several functions. Among them, the model selected as the best is reported in Eq. (3): it is characterized by a very high level of statistical accuracy, as the CoD value is equal to 88.69% and includes most of the explanatory variables considered in the analysis, allowing to determine the contribution of each one in the phenomena of rent price formation.

$$\begin{aligned} Y = &+ 0.74039 * C + 0.65355 * B^{0.5} P^{0.5} + 0.85473 * B^{0.5} * Sc^2 + 11.8431 * \\ &Se^{0.5} * Yc * Dp^{0.5} * Du * Sc^{0.5} + 0.91529 * Sb * F^{0.5} * Me^{0.5} + 3.1017 * \\ &Si0.5 - 2.0858 * Si^{0.5} * F^{0.5} * Dp + 2.5784 * Si * F^{0.5} * Me^{0.5} * E_ab2 + 5.2917 \end{aligned} \tag{3}$$

The intrinsic factors selected by the EPR method and included in the model of Eq. (3) as the most influencing ones in rental housing market are:

- Internal floor surface [Si]
- Surface of balconies, terraces and patios [Sb]
- Presence of condominium areas [Se]
- Floor on which the property is located [F]
- Number of bathrooms in the property [B]
- Excellent quality of the property maintenance conditions [Me]
- EPC labels from A4 to B [E_ab]
- Age of the building in which the residential unit is located [Yc]

The extrinsic factors included in the model chosen are:

- Distance from the nearest university centre [Du]
- Distance from the central pole [Dp]
- Property localization in the central municipal trade area [C]
- Property localization in the semi-central municipal trade area [Sc]
- Property localization in the peripheral municipal trade area [P]

Therefore, the variables not included in the model of Eq. (3) are listed below. In particular, with reference to the study sample analyzed for the city of Milan, these factors are not considered among those most influencing in the housing rental prices mechanism.

- Surface of private external space (green areas, gardens, courtyards) [Se]
- Presence of kitchen located in the same living room of the property [K]
- Bad quality of the property maintenance conditions [Mb]
- Good quality of the property maintenance conditions [Mg]
- EPC labels from C to E [E_cde]
- Distance from the nearest subway [Dm]
- Distance from the central train station [Ds]
- Distance from the nearest urban green space [Dg]

5.1 Interpretation of the Results

The empirical coherence of the functional relationships between the input variables and the rental prices has been verified through a mathematical exogenous approach that allows to quantitatively express the influence of each factor selected by the model of Eq. (3) on the housing rental prices. In particular, the variation of the i-th variable in the range of admissible values in the study sample is analyzed by keeping constant the mean values for the quantitative variables (internal floor surface, surface of balconies, terraces and patios, floor on which the property is located, number of bathroom in the property, age of the building in which the residential unit is located, distance from the nearest university centre, distance from the central pole) and by assuming the value 1 for the dummy variables (presence of condominium areas, excellent quality of the property maintenance conditions, EPC labels from A4 to B, property localization in the central municipal trade area, property localization in the semi-central municipal trade area, property localization in the peripheral municipal trade area), paying attention to any alternative situations for the variables belonging to the same category that cannot simultaneously be equal to 1.

In Figs. 2 and 3 the functional relationships between the intrinsic (Fig. 2) and extrinsic (Fig. 3) variables and the housing rental prices are reported.

Firstly, it should be pointed out that the expected functional correlations between the explanatory variables and the rental prices have been confirmed by those generated by the EPR models. With reference to the intrinsic variable related to the internal floor surface of the property [Si], the factor is linked to the rents through a direct relationship, by attesting a higher market appreciation for larger residential properties. Moreover, the positive percentage variation on rents gradually decreases with increasing of property surface, due to the reduction in the market demand – in term of number of potential lessees able to afford higher monetary amounts for the property renting.

In the city of Milan, according to the study sample considered and to the model selected, the surface of balconies, terraces and patios [Sb] has a positive impact on rental prices: in particular, the average percentage contribution is equal to +4%. In the residential rental market in the context of the city of Milan, the presence of these domestic spaces with a surface area equal to 25 m^2 leads to increase the rental values

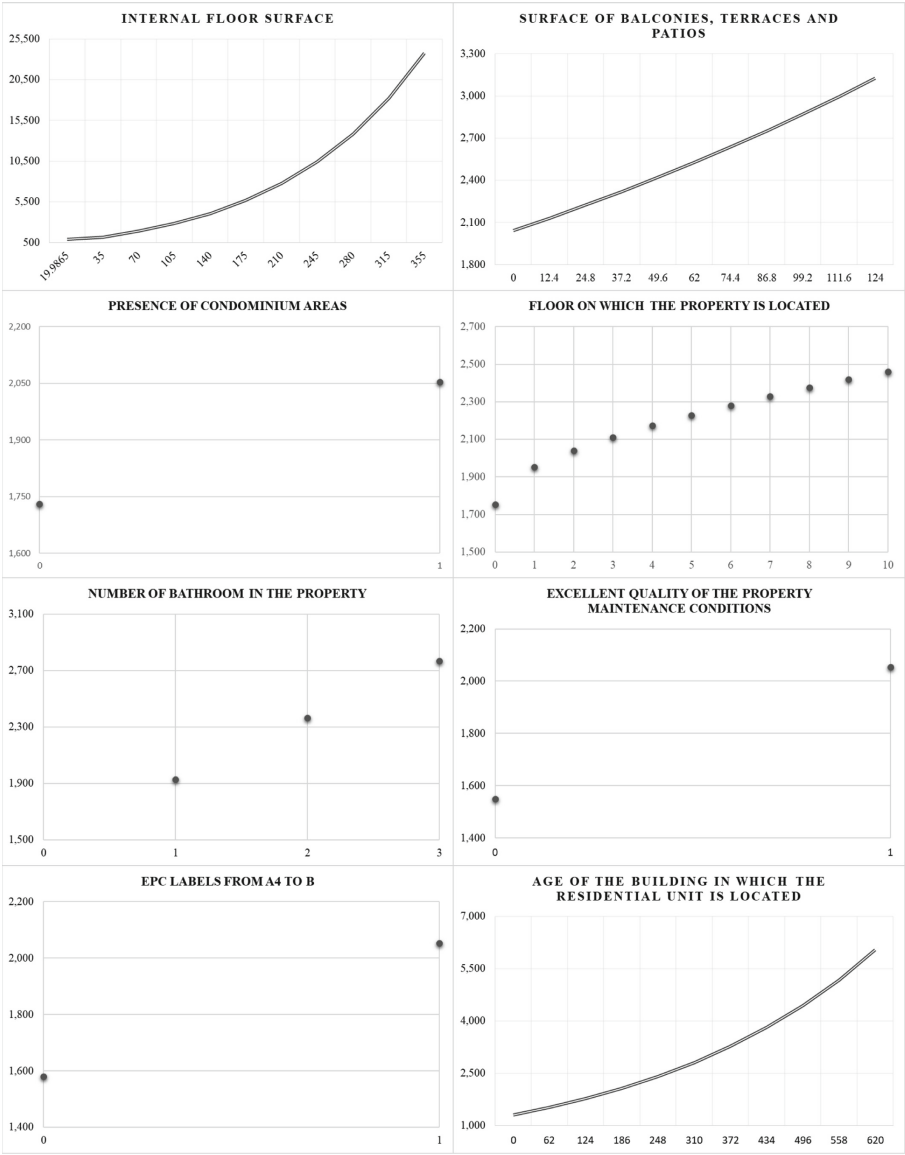

Fig. 2. Functional relationships between the intrinsic factors selected by the model and the housing rental prices

approximately equal to +9% compared to their absence. The contribution of the factor Sb on rental prices decreases progressively as the balconies, terraces and patios surface increases, by denoting a greater importance for these home spaces rather than their dimensions.

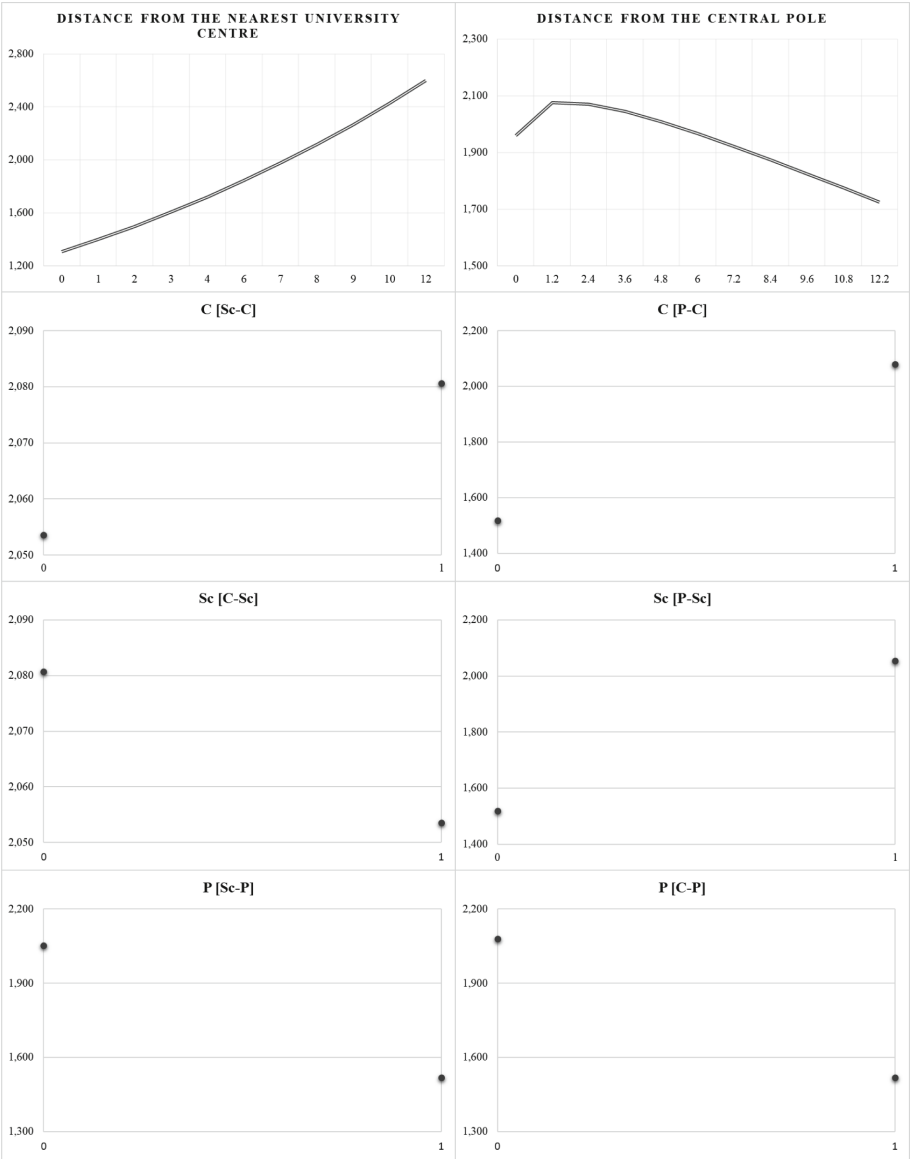

Fig. 3. Functional relationships between the extrinsic factors selected by the model and the housing rental prices

The presence of condominium areas [Se] leads to a growth of residential rents equal to +19%, certifying a relevant influence for the properties characterized by the presence of an area to be used by building residents.

With regards to the intrinsic variable related to the floor level on which the property is located [F], a direct functional relationship has been found (+3%). In particular from the ground floor to the first one the increase of housing rental prices is equal to 11%.

For the number of bathrooms [B], the model generated by EPR for the study sample selected for the analysis is consistent with the expected direct trend, by denoting that an increase of bathrooms number corresponds to high rental values, equal approximately to +26% (from one bathroom to two bathrooms) and to +17% (from two bathrooms to three bathrooms).

A direct functional relationship has been observed also between the dummy variable related to the excellent quality of the property maintenance conditions [Me] and the property rental prices. The average growth observed for this factor is equal to +32%.

The impacts of the energy component in the processes of the housing rental prices formation are relevant: in the model generated by EPR, in fact, the variable for which the variable EPC labels from A to E [E_ab] is included, by demonstrating a direct functional correlation, i.e. an increase in the housing rental prices equal to +30% compared to the residential properties characterized by the lowest energy labels (EPC labels C, D, E, F and G).

With reference to the variable age of the building in which the residential unit is located [Yc] a positive variation in rental prices – approximately equal to +17% - is detected. In this sense, a higher residential rental market appreciation for properties located in historic building compared to those in more recent ones.

An increase in rental prices has been observed at a progressively higher *distance from the nearest university* centre [Du] (on average equal to +7%). The result could be associated to other extrinsic factors that characterize the university districts for which the closeness of university center does not constitute a factor appreciated by potential lessees. Furthermore, it should be noted that the residential properties located in university areas are very often rented to students, by determining the formation of a separate market segment that are usually independent from the general residential rental market. The realization of a University very often gives rise to a phenomenon called "studentification", i.e. the process that leads the residential neighborhoods located close to university centre to become mainly occupied by students. The studentification process often determinates positive impacts on the local real estate market mechanisms, but also it causes negative effects in terms of urban segregation and reduction of housing prices [2, 3, 15, 16, 18, 20, 30].

The model selected points out a parabolic functional relationship between the distance from the central pole [Dp] and the rental prices. In particular, from 0 km to 1.2 km an increase in rental prices is observed (+6%), whereas from 1.2 to 2.4 km a constant trend is detected, beyond which a drop in rental price is found. This confirms a lowest appreciation for the properties facing the central pole, due to other factors that negatively influence the prices (e.g. the chaos for tourist presence, difficulty of finding parking, etc.).

Finally, with reference to the variables related to the municipal trade area in which the property is located, in the model the property position in central municipal trade area [C], in semi-central area [Sc] and in peripheral one [P] are included. In particular, the positive variation on the rental values recorded if the property *ceteris paribus* is located in the central area of the city of Milan is equal to +37% rather than in the

peripheral one, and +1% rather than in the semi-central area. A direct correlation (+ 35%) has been found if the property is located in the semi-central area compared to the central one, whereas an inverse link has been detected passing from the property localization in central municipal trade area to the localization in semi-central one. The inverse relationship with the housing rental prices shows a lower appreciation of the market for the property localization in the peripheral municipal trade area compared to those located in semi-central one (−26%) or in central one (−27%).

In the Fig. 4 a summary of the average contributions of the most influencing factors selected by EPR technique on the housing rental prices has been reported.

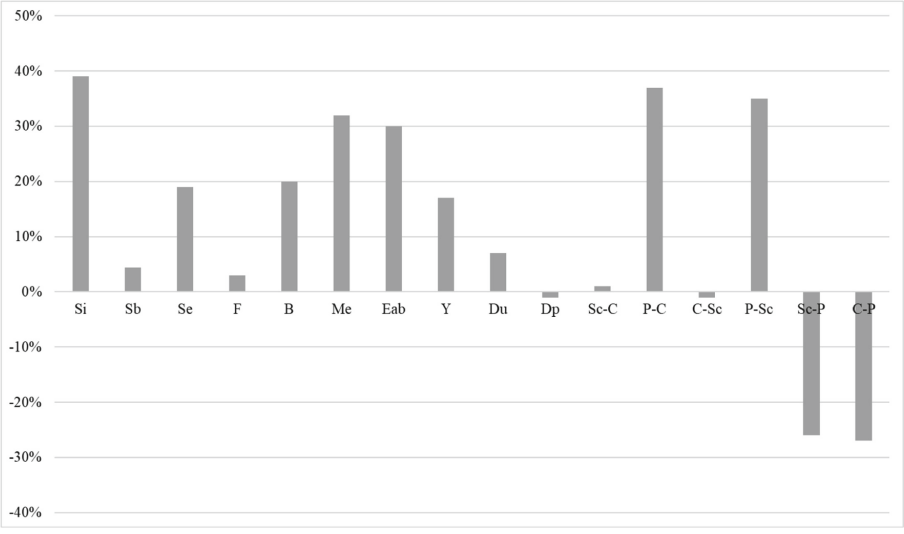

Fig. 4. Average contributions of the most influencing factors selected by the method on the housing rental prices

6 Conclusions

In the present research an analysis aimed to investigate the functional relationships between the intrinsic and extrinsic characteristics and the housing rental prices has been carried out with reference to the Italian city of Milan.

In the current situation related to the Covid-19 the higher market supply – caused by the returning home of non-residential students and workers and by the short-term rental interruption - is allowing a larger quantity of empty residential properties to be rented. In this sense, the potential lessees can choose the property to rent among an increasing number of residential units and in "more accurate" way, e.g. evaluating different factors that so far are not taken into account. Therefore, a variation in housing rental demand in terms of intrinsic and extrinsic characteristics is expected.

The outputs of the present study could represent the first benchmark with which to compare the results deriving from the same analysis to be carried out with reference to

the post Covid-19 in order to examine likely different market appreciations related to property factors.

Further insights may concern the implementation of the method used in the present research to different study samples related to Italian or international cities in order to define the most influential factors on the rental prices in other contexts and to provide for a general framework on the rental market appreciation of potential lessees for investors. For example, with reference to different cities located in the Northern Italy, in the Central Italy and in the Southern Italy and Island, the results of the analysis could be aimed to determine the main determinants on rental values in the macro-areas in which the Italian territory is commonly divided, to address the public decisions toward fair housing policies and to support the private investors in the refurbishment intervention choices.

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