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HOW THE IMPACT OF ENERGY PERFORMANCE CERTIFICATES DIFFERS IN TWO EUROPEAN CLIMATIC ZONES

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Abstract *In the last years, the European Commission stressed the need to include intangible impacts generated by energy efficiency projects in the framework of investments valuation. While direct costs and benefits can be simply quantified using market data, in the case of intangible impacts it is difficult to define a monetary value. Indeed, being considered as off-market goods, it is necessary to refer to parallel markets in close connection with the asset to be valued, or to create a substitute market for the asset in question. In this study, we propose the application of hedonic price method (HPM) approach to evaluate the effect of energy labels derived from the energy performance certificates (EPCs) scheme on buildings' market value. The estimation methodology was applied to two different cities characterized by different climate conditions. In detail, the study starts from two datasets of offer prices advertised between 2014 and 2018 in the cities of Turin (Italy) and Barcelona (Spain). The goal is to understand if the consumers' behaviour is influenced by the sustainable characteristics of the property, and if this differs in dissimilar climate contexts. Ten different models for each dataset have been developed with the aim of capturing not only the marginal price of green buildings features, but also to control the spatial autocorrelation between transactions. Indeed, Spatial Autoregressive Model (SAR) and Spatial Error Model (SEM) have been implemented within the traditional hedonic model for the identification of the spatial influence between the properties prices. The hedonic spatial models demonstrated the appreciation for the green characteristics of the buildings in both cities, although to a different extent.*

1. INTRODUCTION

In addition to environmental impacts, the scientific literature has recognized a number of benefits related to the economic and social sphere. Positive impacts as the greater value of the property, reduced outages and disease events, improved indoor comfort and better occupants health occur [1]. If direct effects, such as energy saving, are easy to quantify and monetize as they refer directly to the real market, for intangible impacts it is not so simple [2]. To estimate these out-of-market impacts it is necessary to refer to the revealed or stated preference methods (RP or SP). RP methods evaluate the economic value of a good or service through market data. The two most common techniques in this context are the travel cost method (TCM) and the hedonic price method (HPM). This latter assumes that the value of an asset is influenced by its characteristics, so the goal is to break down the good into its relevant attributes and evaluate them separately [3]. The following study aims to define the benefit related to the increase in real estate value of green buildings starting from two datasets that refer to two cities located in different climatic zones; Turin (Italy) and Barcelona (Spain). The method used to estimate the benefit is that of the HPM, widely used in literature for this purpose [4]. The traditional model has been implemented with a Spatial Autoregressive Model (SAR) and a Spatial Error Model (SEM) that introduce spatial effects into the hedonic function [5].

2. REVIEW ON HEDONIC PRICE APPLICATION

In recent years, specific studies have been developed to assess how energy efficiency affects the properties' value by applying HPM [3]. Many studies demonstrated that the green features have positive effects in the form of increased rental rates, higher sales price, and lower operating costs. [6] investigated the value of Green Mark in Singapore and found a statistically significant price premium compared to non-rated projects. [7] revealed the contribution of energy efficiency to the real estate property value in Padua (Italy) applying HPM to a dataset of 1,042 property advertisements. In Helsinki, a HPM yields a statistically significant 3.3% price premium for apartments in the top three energy-efficiency categories [8]. The Finnish cold climate has a strong influence on energy consumption for heating, therefore energy efficiency measures play a key role.

3. APPLICATION

From the geographical point of view, Barcelona and Turin are located within the Mediterranean climate zone differentiated by climate sub-category. Both the cities depict the same building distribution, with a wide development in the post-war period, especially in the outlying areas. As it is well known, the buildings built during this period did not follow any energy regulation, determining a heavy energy-consuming building stock. The study proposed in this paper follows a multi-step methodology. First of all, the data of the transactions in terms of price and characteristics of the housing were collected from listings coming from the main real estate agencies of Turin and Barcelona respectively. The period taken into consideration refers to the years from 2014 to 2018. Data collection mainly

concerned the building typology of multi-family buildings for both case studies. The second step was the definition of the explanatory variables, paying great attention to the availability of information to the energy class (EPC). In Europe, it was mandatory the inclusion of the energy efficiency certificate of the properties at the time of sale and rent. Nevertheless, only 15%-17% (for the year 2014 and 2016 respectively) of the ads has this information in Barcelona. This led to the elimination of many observations. Once all the valid observations were collected, further tests were carried out to identify the collinear variables and the possible outliers guilty of influencing the estimation. Table 1 shows the independent variables taken into consideration in the model, as well as the dependent variable of the total listing price for the two datasets.

Table 1: Datasets variables list

		Barcelona (3'545 observations)				Turin (15'295 observations)			
Variables	Measure	Min	Max	Mean	St.Dv	Min	Max	Mean	St.Dv
Surface (m^2)	Scale	20	600	103.63	59.772	20	578	90.73	46.88
EPC (A=1;… G=7)	Ordinal	1	7	4.12	1.33	1	7	4.86	1.68
Floor level	Scale	0	24	2.64	2.49	0	15	2.88	2.14
Elevator	Nominal	0	1	0.76	0.42	0	1	0.73	0.44
Retrofitted (to be retrofitted/good=0; retrofitted/new=1)	Nominal	0	1	0.18	0.387	0	1	0.50	0.490
Year (2014=1;… 2018=5)	Ordinal	1	3	2.27	0.960	1	5	3.55	0.918
Total listing price (€) (dependent)	Scale	34'000	7'670'000	400'147	375'386	90'000	3'600'000	186'672	17'506

4. RESULTS

Different regression models have been applied considering "Total listing price" as dependent variable. In the case of Barcelona, the Ordinary Least Squares (OLS) regression models doesn't work very well for the estimation of EPC coefficient. Only in the case of log-lin model the EPC is significant. On the other hand, the EPC coefficient for Turin case is significant and expresses a willingness to pay to move from one class to another equal to 10,174€ (R^2=0.77), considering all the variables mentioned in Table 1. Before to apply SAR and SEM models, a global spatial autocorrelation analysis was performed for each dataset. For this purpose, in the present study the free software GeoDa [4] was employed. Once selected the queen contiguity weight matrix, the Moran's Index (MI) was calculated for each dataset. In the case of Barcelona, a great level of spatial

autocorrelation is present (0.622851 MI). In the Turin's case, the index indicates an autocorrelation discrete level (0.267487 MI), due probably to the presence of some outliers. A spatial pattern of real estate values is recognized by the SAR and SEM models in both cities. The log-log SAR model works better in Barcelona, where a high value of MI is verified (R^2=0.825). A better value of R^2 is given by the log-log SEM model for for Turin (R^2=0.810). The results of spatial models are shown in Table 2 and 3. The previously identified explanatory variables were reduced in the models in order to pass the statistical significance test.

Table 2: Barcelona's dataset regression model results - Nonlinear spatial autoregressive model (log-log)

Variable	Coefficients (β)	Std. Error	z-values	Sig.
(Constant)	2.04169	0.1089570	18.7385	0.0000
Surface (m^2)	0.933091	0.0145001	64.3505	0.0000
Floor level	0.0660551	0.0078252	8.4413	0.0000
Elevator	0.15104	0.0197005	7.66684	0.0000
Retrofitted	0.174713	0.0199539	8.7558	0.0000
EPC	-0.0220865	0.0104003	2.12363	0.0337
Year	0.105682	0.0100524	10.5132	0.0000

R^2	0.825166	Log likelihood	-1001.46	Akaike info criterion	2018.92
Total price (mean)	400'147	Estimate std. err.	0.31420	Schwarz criterion	2068.30

Table 3: Turin's dataset regression model results - Nonlinear spatial error model (log-log)

Variable	Coefficients (β)	Std. Error	z-values	Sig.
(Constant)	6.65032	0.0360667	184.389	0.0000
Surface (m^2)	1.26959	0.0063997	198.381	0.0000
Elevator	0.0628708	0.0029162	21.5589	0.0000
Retrofitted	0.286435	0.0079121	36.2021	0.0000
EPC	-0.301771	0.0086586	-34.8521	0.0000
Year	-0.0778839	0.0101570	-7.668	0.0000

R^2	0.814644	Log likelihood	-4367.88	Akaike info criterion	8747.76
Total price (mean)	186'672	Estimate std. err.	0.31432	Schwarz criterion	8793.57

CONCLUSIONS

Starting from a sample of apartments located in the city of Turin and Barcelona, the paper has shown the application of different estimation models based on the HPM aimed to the analysis of the contribution of the energy certification to the real estate market value. The explanatory variables shown appropriate amount and signs, as commented below. In Barcelona, living on high floor is appreciated by the consumer, such as the presence of lift in the building. In the case of Turin, the variable does not result significant. A refurbished or new apartment has a higher market value as to be expected. This is confirmed by the

fact that in both cities, the residential real estate market is characterized by a high percentage of old and energy-consuming properties, as explained above. The results show the existence of a consumer's appreciation for efficient buildings from the energy point of view. The EPC coefficient is much less important for the city of Barcelona but there is no evidence that the effect of the EPC is differently appreciated because the cities are located in two distinct climate zones. Further investigations will be developed by testing the presence of the air conditioner in the apartments of Barcelona where the climate is characterized by dry and hot summer. Finally, a different price trend over time is recorded in the two case studies. The real estate market of Turin, in recent years, has been characterized by a decrease in the properties prices. On the other hand, in Barcelona there was an increase in property values caused by a different economic trend. As a future perspective, the research could investigate the use of political administrative units, such as cadastral or census districts, in order to provide more expendable and immediate findings. Future works could also be devoted to the inclusion of the time variable in the estimating, making use of more sophisticated models based on bigger databases.

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