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CAPITALIZATION RATE AND REAL ESTATE RISK FACTORS: AN ANALYSIS OF THE RELATIONSHIPS FOR THE RESIDENTIAL MARKET IN THE CITY OF ROME (ITALY)

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ABSTRACT

The assessment of income-producing properties - considered as the bulk of the existing assets - has rapidly increased. An efficient assessment of the market value of this kind of properties requires an adequate involvement of the main risk factors of the local real estate market for the determination of the capitalization rate for the income approach application. The aim of the work is to identify the most significant local real estate risk factors related to the market, the tenant and the context on the residential capitalization rate. The development of a regressive methodological approach applied to the residential sector of the city of Rome (Italy) is proposed. The obtained results show the susceptibility of the analyzed capitalization rate to the variation of the local real estate risk factors, in particular the per capita income and the variation of the rental values, by also considering the influences of the exogenous shocks and the expectation of the investors. The practical implications of the work consist in the possibility for evaluators to assess the likely changes in the capitalization rate in different residential contexts if variations occur in the most influential local risk factors identified by the proposed model.

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1. Introduction

National and international policies promote renovation activities of existent real estate assets for achieving sustainable urban development goals. Most of the existing assets consist of income-producing properties that have the feature of producing a stream of income (Tajani et al., 2018). In Italy, the residential sector is one of the main sources of income-producing properties, headed by the capital city of Rome, which has had an annual average of about 2,800 residential units in the last 10 years (www.idealista.it).

The assessment of the income-producing properties considers different variables that could affect the market value. In fact, the income approach is based on three different methods: income capitalization, discounted cash flow and various option pricing models (IVS, 2022). Through this approach, the assessment of the most likely market value is built on two fundamental variables for these properties: net operating income and capitalization rate. The first one, is intended as the income generated by properties without the expenses on the owner's part. The capitalization rate is an unknown and not fixed

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variable that can't be directly collected from the real estate market. For these reasons, several evaluation techniques have been developed for its determination (Austin, 2012; Pivo 2010).

In the field of investment risk, the capitalization rate is generally considered one of the most important variables (Anelli & Tajani, 2023). If a slight variation of it occurs, this can affect the result of the risk investor's analysis. The explanation is easily attributable to its algebraic definition: the ratio between the net operating income and the market value of the property. It can be possible to observe that the capitalization rate could be susceptible to those factors that influence the determination of both the net operating income and the market value of the income-producing properties. In several studies, it has been highlighted how the evaluation of the market value of an income property defines a set of current market conditions and economic trends or how, vice versa, real estate markets are influenced by the economy, investor interests and fiscal factors (Roulac, 1996; d'Amato, 2010). With this regard, the most critical issue concerns the utilization of an adequate capitalization rate that is able to reflect all dimensions of risk that impact rental income streams and the market value of these properties; therefore, the capitalization rate includes both macroeconomic and local risk factors (Manganelli et al., 2014; Gabrielli & French, 2020). It is thus considered as a complex variable in which the interaction of numerous factors that behave at property and macroeconomic levels is condensed (Chaney & Hoesli, 2012). According to Philips (1998), the capitalization rate of residential real estate properties varies in different metropolitan areas, and reflects numerous factors, such as inflation rate, the cost of capital, local taxes and policies across the regions.

Despite the importance assumed by the assessment of the income-producing properties of the residential sector, the international scientific panorama is more focused on the capitalization rate of offices. One of the main reasons is the greater difficulty of finding available data for determining the capitalization rate. Actually, several gaps can be identified: i) scarcity of studies aimed at determining the most influential real estate risk factors on the capitalization rate of the Italian residential sector, especially for the city of Rome; ii) absence of analyses concerning the sub-municipal territorial scale; iii) lack of studies that investigate the relationships between specific local risk factors and the capitalization rate.

The analysis of the effects of specific local risk factors on the residential capitalization rate constitutes the aim of the present work. Determining the likely variations of the capitalization rate by considering the significance of certain risk factors using a regression model can be useful for supporting professional practices in order to fill the recognized gaps.

2. Aim of the work

The aim of the work is to identify the local real estate risk factors that most affect the capitalization rate of the residential sector. The research's aims are pursued through the development of a regressive-based methodological approach that consists of 4 phases: i) examination of the reference literature for identifying the 12 real estate risk factors to be analyzed for residential income-producing properties; ii) identification of the variables capable of representing each risk factor selected in the analysis of the residential capitalization rate, iii) collection of data and construction of the analysis sample; iv) application of the stepwise regression model for identifying the most significant risk factor variables, and for defining the relationships between the selected variables and the capitalization rate. The proposed methodological approach is applied to the city of Rome (Italy) and the analyses are carried out on a sub-municipal territorial scale of the 213 homogeneous real estate market areas identified by the Real Estate Market Observatory of the Italian Revenue Agency.

The new quality that this methodological approach brings at the international and national level is represented by the possibility of supporting valuers in determining the capitalization rate of the residential sector: by knowing that a modification of the real estate risk factors selected by the model as the most influential ones occurs, according to the relationships determined by the model, the capitalization rate could be easily assessed. Moreover, the model describes the capitalization rate determination for residential properties at the sub-municipal scale in a transparent and rigorous manner. Finally, another practical implication of the analysis is the possibility to classify, in other cities of Italy, Europe and the world, the investment risk according to the main factors selected by the different models generated by the applied methodology. The evaluation standards highlight the role of the capitalization rate as an indicator of the perceived investment risk in the real estate market (IVS, 2022).

The remainder of the paper is structured as follows: Section 3 provides for a literature review on similar topics; Section 4 describes the data and the methodology; Section 5 shows the results and their coherence with the empirical evidence; Section 6 formulates the conclusions of the work and considers the future developments.

3. Literature review

It is possible to divide the real estate risk into two main groups: the first one -so-called macroeconomic, because it is related to the global market dynamics, and the second one - so-called local, which concerns the local structures of the real estate market that characterize the surrounding context of the properties. The relevance that both groups of real estate risk factors can have on the streams of income is also acknowledged in the professional appraisal practices and in the evaluation standards (IVS, 2022), and the European Valuation Standards (2020) published by The European Group of Valuers' Associations (TEGoVA).

3.1 Capitalization rate's influencing risk factors for income producing properties

Capitalization rate of income-producing real estate is considered as an economic variable for its sensitivity to the global environment and macroeconomic factors, such as interest rates, inflation, availability of capital, house price movements etc. (Peyton, 2009; Chuangdumrongsomsuk & Fuerst, 2017; Napoli et al., 2017; Letdin et al., 2022). Theoretically, as stated by Simons et al., (2011), the capitalization rate could be seen as a linear combination of the following economic variables: real mortgage rate, the local taxation, maintenance status and expected capital gain. Other factors include inflation rate and housing price variation. In the literature, there are several studies that have examined the effect of the macroeconomic environment and factors on capitalization rates; some important results are can be found in : Kim et al. (2018), who observed that capitalization rates of commercial sectors decrease if the liquidity of six Asian financial market increases; Chen et al. (2004) who, by examining the interaction between capital markets and net operating income, show how capitalization rate is the connecting variable between them; Clayton et al. (2009) who, by specifying that capitalization rates can be considered as a function of real estate space and capital market fundamentals, determine expected rental growth, equity risk premiums, T-bond yields, and lagged adjustments on the long run equilibrium as primary drivers and determinants of capitalization rates; Chervachidze and Wheaton (2013), who realize how three macroeconomic variables, i.e. real treasury rate, bond risk premium and expansion of growth rate of debt relative to GDP (general market liquidity), are extremely important. Chichernea et al. (2008) argue that the increase in residential demands, supply contracts and liquidity crisis have a significant effect on capitalization rate. The evidence allows to say that the macroeconomic real estate risk factors can affect the capitalization rate of income producing properties in different ways, based on three variables: i) period of time; ii) real estate sector and iii) territorial scale (Devaney et al., 2019). Thibodeau and Peng (2012) place the capitalization rate within the Dividend Pricing Hypothesis (DPH) as one of the two components of housing investment risk. According to this theory, in an efficient housing market, where there is the existence of a no-arbitrage equilibrium that equates total risk-adjusted housing returns in different markets, there is a trade-off between the capitalization rate and the future appreciation rate. In the specification used by Feng (2015) for estimating the capitalization rate by testing the DPH across the markets of different cities, the capitalization rate is a function of a vector representing the housing characteristics. Geltner et al. (2007) claims that the capitalization rate is affected by the opportunity cost of assets, expectations of investors on increasing prices/rents, and the risk. Meanwhile, Tian (2013) suggests that the capitalization rate of residential properties is mainly linked to interest rates and expected price. Within the Dividend Discount Models, D'Amato (2015) re-define cyclical capitalization models as an income approach model that takes property market cycles into account. The proposed models belong to a wider group of assessment methodologies founded on the integration of the income approach with the analysis of regular and irregular property market cycles. These models can be particularly useful when frequent up and down phases of the market cycles occur in the process of evaluating income-producing properties.

At the local scale, fewer studies can be retrieved, but some of these are noteworthy for the significance of achieved results, consistent with the aims of this research. Fisher et al., (2020) show that properties placed in high-density locations experience higher net operating income growth, earn higher risk-adjusted returns, and carry out higher systematic risk than their

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otherwise comparable counterparts in low-density locations. The Authors highlight that real estate risk factors that express urban context features are significant drivers of capitalization rate and can have an important role in the sub-municipal distribution differences of capitalization rates. Given the increasing attention given to the environmental impacts of buildings, McGrath (2013) explores whether such features would be quantified in the capitalization rates of eco-certified offices. His study demonstrates that buildings with ecological features have lower capitalization rates than ones who do not possess such attributes. Factors, such as lot and building size, location and building age, are used as independent variables to see the influence and correlations with the capitalization rates as the dependent variable in the study carried out by Prasetyanto and Sasana (2020). The selected variables appear to be statistically significant in explaining the capitalization rates of a sample of 5 residential assets ubicated in Indonesia. Another important risk factor characterizing the local real estate market and the related dynamics is the benefit produced by the walkability distances. Pivo and Fisher (2011) find that properties located in urban and suburban centers with high population density and within favorable proximity (walkability) should have lower capitalization rates relative to properties located in scarcely populated zones, therefore investors are willing to pay price premiums for properties that have high "Walkscore". Chaney and Hoesli (2015) identify several variables and categories of variables that explain capitalization rates. These include property-specific risks (such as land leverage, ownership leverage, refurbishment risk and illiquidity risk, construction quality, building condition), and micro-level risk categories, such as tenant diversification, tenant risk, regulatory risk. Elliehausen and Nichols (2012) analyze over 8,000 samples of capitalization rates of offices between 2001 and 2009 in the Real Capital Analytics (RCA) database. The regression model with variables related to macro fundamentals, property-level characteristics, type of buyers, type of sellers and local market conditions, shows that the local market features explain the greatest part of variation in capitalization rates. The research of Sivitanidou and Sivitanides (1999) demonstrates the important role that local market conditions play in determining differences in capitalization rates both across metropolitan areas and over time.

Despite the segmentation acknowledged by the municipal areas of the real estate markets, very few studies have focused on the specific capitalization rates of sub-municipal zones.

3.2 Stepwise regression applications for the capitalization rate's analysis

One of the most common statistical and machine learning algorithms are linear regression models. Their suitability in finding the linear relationships between one (simple linear regression) or more (multiple linear regression) variables (Larriva, 2022) are their main features. Numerous studies apply the linear regression models for examining the real estate market's capitalization rate. For example, Letdin et al., (2022) use an Ordinary Least Squares (OLS) regression model with capitalization rate as a dependent variable and including macroeconomic factors, property, location and tenant characteristics, deal-level controls, and lease terms. The achieved results highlight the relevant influence of the tenant characteristics. Unbehaun and Fuerst (2018) assess the impact of location on capitalization rates and risk premia by considering temporal, spatial and economic explanatory variables of Central Business Districts through a hedonic regression model. Their findings confirm the importance of local real estate risk factors, especially the ones related to the urban context. Netzell (2009) apply a regression analysis to the capitalization rates by considering property characteristics and the produced income to capture time series variation in capitalization rates. His results show that, for the most part, appraisals do not deviate from the expected pattern and do not exhibit irrationality.

Among the several typologies of existing regression models, the stepwise regression analysis is widely used in the real estate market assessment and study, especially for understanding how the variance explained changes by adding (or removing) each predictor to the model, one at a time (Cui, 2020). According to Desboulets, 2018, stepwise regression has a solid basis and is the most well-known and the most widespread technique for choosing variables in a regressive model. Ranjan and Mishra (2021) conduct risk factors analysis for real estate price prediction using multiple linear regression, stepwise regression, and support vector regression. Yilmazer and Kocaman (2020) compare stepwise linear multiple regression and the random forest approach for mass appraisal in an urban residential area, whereas Jafari and Akhavian (2019) include the stepwise regression in a four-step

framework to identify the key characteristics that determine housing prices in the USA. Despite its usefulness, very few studies have been carried out in the field of capitalization rate, most of which took place many years ago: Bleich, (2003) uses a stepwise regression model to assess the effect of an earthquake on apartment buildings' overall capitalization rates; Rosen and Vandayke (2001) use the stepwise regression to deduce explanatory variables which have the highest statistical importance in explaining the dependent variable, or the office capitalization rate; Froland (1987), by using a stepwise regression approach, explains about 86% to 95% of the variation in capitalization rates by the mortgage rate, the eight-quarter bond-bill spread, and the price earnings ratio.

4. Material and methods

4.1 Stepwise regression model

In order to detect the most influential local real estate risk factors on the capitalization rate of the residential sector and to define the existing relationships between them and the residential capitalization rate of the city of Rome, a stepwise multiple regression model is developed. The stepwise regression is the step-by-step iterative construction of a regression model that involves the selection of predictors (explanatory variables) to be used in the final model that explains the relationships among the dependent variable and the independent ones. The application of stepwise regression is useful in cases where it is necessary to select an "optimal" subset of variables among those initially considered, as in the present research.

The stepwise regression model determines the best combination of explanatory variables which have the smallest t-test and the p-value under 0.05. The used stepwise regression model is the "forward selection" that i) begins with only the constant term in the model but no predictors, ii) tests each predictor according to a specified fit criterion, in this case the F-test, to add to the model, and then iii) keeps those that are deemed most statistically significant, repeating the process until all the results are statistically significant. Each of the predictors is a candidate to be entered into the stepwise regression model: at each step, the predictor with smallest t-test and p-value is added to the stepwise model. If the predictor, on the other hand, has a p-value that exceeds the 0.05 value, it is removed from the stepwise model. The stepwise regression automatically stops running when all the predictors in the model have p-values of less than the set α value (0.05), and all the predictors not in the model have a p-value above it.

The inclusion of the dependency of additional predictors in the model is investigated through the Extra Sum of Squares Test applied individually for each of the predictors still under consideration. A variable which had already been previously introduced can be redundant by virtue of the introduction of new variables. Once the final statistically significant model is defined, hypothesis tests are conducted on the individual parameters to determine whether each predictor makes a significant contribution to the model.

4.2 Features of the case study's sample

The stepwise regression model is applied to a sample that refers to the 213 homogeneous real estate market zones provided by the subdivision of the Real Estate Market Observatory (REMO) of the Italian Revenue Agency on the second semester of 2020, for the city of Rome (Italy). A pivotal process of the activities of the Observatory is defined by the definition of REMO zones, that is, homogeneous areas of the market within which historical data on purchased and rented real estate units are collected. In particular, the REMO area is defined as a continuous portion of the territory reflecting a homogeneous segment of the local property market, in which there is uniformity of appreciation for economic and socio-environmental conditions. The basic hypothesis is, therefore, that the «positional factor» is the most explanatory factor of the differences in values between the various areas, in particular those designated for residential use.

For each of the homogeneous areas, the dependent variable, or the residential capitalization rate, and 12 selected explanatory variables are collected. The factors influencing the capitalization rate are based on literature - on arguments, theory and prior observation, in order to detect all the aspects that affect the capitalization rate in the market. In particular, the variables chosen to be analyzed are consistent with the studies of Fisher et al., (2020), Pivo and Fisher (2011), Chaney and Hoesli (2015) and Elliehausen and Nichols (2012). For more details, see sub-paragraph 3.2. However, it is important to note that even if the 12 variables are specifically related to the local scale, their variations could also be correlated with the dynamics of the macroeconomic risk factors of the global markets. A list of the considered variables and the related

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description, acronym, source and reference data are provided in Table 1.

Table 1

List of the sample's variables with their description, acronyms and source/data

TYPE OF VARIABLE	VARIABLE and ACRONYM	MEASUREMENT METHOD	SOURCE/DATA
Dependent	Capitalization rate of the residential sector (CP)	This is the average capitalization rate determined for the residential rental sector in the homogeneous real estate market zone.	Real Estate Market Observatory quotations of the Revenue Agency –second semester 2021
Explanatory	Variation of residential sales values (VRS)	This is the standard deviation of the residential sales values in the last 5 years in the homogeneous real estate market zone. The standard deviation can express the volatility of the sales values.	Real Estate Market Observatory quotations of the Revenue Agency – from the first semester of 2015 to the second semester 2020
	Average residential sales times (ARST)	This represents the average number of months that exist between the date of appearance of the real estate sale listing and its removal for considering the level of dynamism of the local selling real estate market. The number of months is often used for analyzing the time on market of the properties.	Immobiliare.it database – from the first semester of 2015 to the second semester 2020
	Variation of residential rental values (VRR)	This is the standard deviation of the residential rent values in the last 5 years in the homogeneous real estate market zone for detecting the variation of them. The standard deviation can express the volatility of the sales values.	Real Estate Market Observatory quotations of the Revenue Agency – from the first semester of 2015 to the second semester 2020
	Average residential rental times (ARRT)	This represents the average number of months that exist between the date of appearance of the real estate rental listing and its removal for considering the level of dynamism of the local rental real estate market. The number of months is often used for analyzing the time the properties have been on the market. .	Immobiliare.it database – from the first semester of 2015 to the second semester 2020
	Attractivity level (AL)	This expresses the attractiveness level of the urban context within the homogeneous real estate market zone in terms of the average number of people passing through the zone between 8.00 a.m. and the 8 p.m. It is a proxy measure for the utilization of the area.	Urbistat Geosoftware database – 1 January 2021
	Property maintenance costs (MC)	This indicate the average per capita property maintenance costs that the households sustain for ordinary maintenance interventions. It is used as a proxy of the property maintenance conditions.	Urbistat Geosoftware database – 1 January 2021
	Empty properties (EP)	This is the rate of abandoned or unused properties in the homogeneous real estate market zone as the percentage of the number of existing properties. It is used as a proxy of the urban quality level.	Urbistat Geosoftware database – 1 January 2021
	Per capita income (PCI)	This consists of the per capita income per year. It is a proxy for the financial stability of tenants.	Urbistat Geosoftware database – 1 January 2021
	Households living in owned apartment (PA)	This is the percentage of households living in owned apartments. It is used for measuring the title of the use of the house.	Urbistat Geosoftware database – 1 January 2021
	Households living in rented apartment (RA)	This is the percentage of households living in rented apartments for measuring the financial instability of tenants. It is used for measuring the title to the house.	Urbistat Geosoftware database – 1 January 2021
	Unemployment rate (UR)	This is the percentage of non-workers on the total resident population of working age. It is a proxy for the tenant risk.	Urbistat Geosoftware database – 1 January 2021
	Population density (PD)	This measures the number of inhabitants per km^2. It represents the potential demand of the homogeneous real estate market zone	Urbistat Geosoftware database – 1 January 2021

Source: own study.

The data sources used for collecting the overall 13 variables relate to three different databases: the first

one is the Revenue Agency that is the main national reference for acquiring semestral updated real estate quotations of residential, commercial, tertiary and productive sectors, used by both academicians and private practitioners; the second one is *Immobiliare.it,* which is the most employed and numerous real estate ad site of the Italian context; the last one is *Urbistat Geosoftware,* which is a private database that collects data from different sources, such as the National Statistical Institute. Among the 12 explanatory variables selected for the case study, there are some differences according to their capacity of representing specific aspects of the local real estate risk factors. In particular, the "Variation of residential sales values" (VRS), the "Average residential sales times" (ARST), the "Variation of residential rent values" (VRR) and the "Average residential rental times" (ARRT) are 4 explanatory variables that represent the main factors contributing to the risk market formation process. In fact, the first variable (VRS) indicates the stability or instability of the selling residential values by considering the period of time of 12 semesters in the last 5 years (from the first semester of the 2015 to the second semester of 2020), in order to detect, through the determination of the standard deviation, the variation of the selling market values. The second (ARST) can give information on the dynamism's level of the local real estate market, due to the importance attributed to the number of months in which a real estate listing remains published on property advertisement sites. The ARST variable refers to a period that is the same as of the VRS variable, therefore from the first semester of 2015 to the second semester of 2020. The third (VRR) and the fourth (ARRT) variables are aimed at explaining the same issues of the first two variables, that is the VRS and VRR, but on the rental market segment instead of the selling one.

The "Attractivity level" (AL), the "Property maintenance costs" (MC) and the "Empty properties" (EP) explanatory variables are considered for expressing the factors that influence the risk related to the urban context's features of the local real estate market for each homogeneous zone. In fact, due to the fact that the territorial unit of analysis corresponds to an area and not to an individual property, the urban context's features that are generally considered to explain the related risk factors in real estate market analysis (e.g. infrastructure level, services, green spaces, accessibility etc.) are synthetized under these 3 variables. The first variable (AL) gives information on the number of people passing through the homogeneous zone - indifferently distinguished between workers, residents, tourists etc. – between 8 a.m. and 8 p.m. In this way, the potential attractiveness level of the entire spatial market zone can be considered. It is not an absolute way for expressing attractiveness, but it is consistent with the aim of the work and other studies considered in sub-paragraph 3.2. The second variable (MC) can be a proxy of the property's maintenance status of the homogeneous market zone, because if the per capita expenditure is great, it means a poor maintenance condition or construction material, if instead the per capita expenditure is low, it means a good/optimum maintenance condition or construction material. The EP variable, instead, is used to examine the presence of abandoned or unused buildings that can represent detractors of the urban quality level, as also confirmed by several studies (Maghelal et al., 2014; Ferreira et al., 2018; Pinto et al., 2021).

The last five explanatory variables, or the "Per capita income" (PCI), the "Households living in owned apartment" (PA), the "Households living in rented apartment" (RA), the "Unemployment rate" (UR) and the "Population density" (PD) are characterized by the ability to take into account the features of the potential tenants of residential income producing properties and, therefore, the tenant's risk. The PCI, the PA, the RA and the UR variables, in fact, express all the financial stability of the tenants in the homogeneous market zone, but under different aspects. The PCI assesses the tenants' financial availability and purchasing power, the PA and the RA highlights their real estate holdings and the UR, instead, stresses their financial instability. The PD explanatory variable can indicate how extensive the potential tenants' demand for income producing properties in the market zone could be. The descriptive statistics of the 12 explanatory variables are reported in Table 2.

The correlation analysis is conducted for revealing the strong and weak correlation relationships among the considered variables. In Table 3, Pearson's correlation matrix is represented.

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Table 2

Descriptive statistics of the explanatory variables

VARIABLE	MEASURING SCALE	MIN.	MAX.	MED.	ST.DEV.
VRS	Number	0.00	0.21	0.08	0.03
ARST	Number	4.64	9.78	6.40	1.00
VRR	Number	0.00	0.17	0.07	0.02
ARRT	Number	2.67	9.78	4.86	0.92
AL	Number	259.00	71,756.00	13,990.28	12,107.18
MC	€/inhabitant	25.56	485.03	150.81	77.84
EP	%	0.00	37.60	11.05	7.62
PCI	€/inhabitant	8,837.00	58,402.00	22,018.48	8,234.28
PA	%	12.70	87.70	68.41	10.42
RA	%	3.60	77.40	19.72	11.00
UR	%	3.50	34.80	8.35	3.30
PD	Inhabitant/km^2	29.60	9,256.31	2,4793.26	5,684.48

Source: own study.

Table 3

Pearson's correlation matrix

	VRS	*ARST*	*VRR*	*ARRT*	*AL*	*MC*	*EP*	*PCI*	*PA*	*RA*	*UR*	*PD*
VRS	1.000	0.074*	0.674**	-0.120*	-0.196*	-0.555**	-0.057*	-0.564**	0.025*	0.009*	0.209*	-0.346**
ARST	0.074	1.000	0.012*	0.327**	-0.339**	-0.052*	0.245*	-0.053*	-0.057*	-0.216*	0.011*	-0.528**
VRR	0.674	0.012	1.000	0.090*	-0.135*	-0.197*	-0.066*	-0.186*	0.074*	-0.109*	-0.115*	-0.211*
ARRT	-0.120	0.327	0.090	1.000	-0.097*	0.194*	0.152*	0.213*	0.111*	-0.204*	-0.241*	-0.211*
AL	-0.196	-0.339	-0.135	-0.097	1.000	0.278*	-0.075*	0.312**	0.019*	0.082*	-0.145*	0.486**
MC	-0.555	-0.052	-0.197	0.194	0.278	1.000	0.224	0.958***	-0.118*	-0.009*	-0.424**	0.315**
EP	-0.057	0.245	-0.066	0.152	-0.075	0.224	1.000	0.232*	-0.080*	-0.180*	-0.014*	-0.296*
PCI	-0.564	-0.053	-0.186	0.213	0.312	0.958	0.232	1.000	-0.119*	-0.015*	-0.448**	0.294*
PA	0.025	-0.057	0.074	0.111	0.019	-0.118	-0.080	-0.119	1.000	-0.598**	-0.376**	0.023*
RA	0.009	-0.216	-0.109	-0.204	0.082	-0.009	-0.180	-0.015	-0.598	1.000	0.647**	0.219*
UR	0.209	0.011	-0.115	-0.241	-0.145	-0.424	-0.014	-0.448	-0.376	0.647	1.000	-0.089*
PD	-0.346	-0.528	-0.211	-0.211	0.486	0.315	-0.296	0.294	0.023	0.219	-0.089	1.000

Note: * is for low correlation < 0.3, ** is for moderate correlation < 0.7 and > 0.3, *** is for strong correlation > 0.7.
Source: own study.

As can be seen in Table 3, the general level of correlation is low. Among the explanatory variables of the tenant risk factors, a strong correlation exists between the PCI and the MC variables. This is due to two main reasons: the first is that the resident population with a greatest per capita income represents a large part of the population living in properties built before 1950, which therefore require ordinary maintenance works more frequently; and the second is that a greater availability of income can lead to a greater propensity to spend money on the necessary ordinary maintenance works. For the market risk factors, the VRS and the VRR have a moderate level of correlation equal to 0.674, therefore representing a positive link between the two variables. This coincides with the expected results, and can be explained by the well-known strong relationship between the sales and rental market in the city of Rome, according to the recent trend analysis. The analysis and the average variation of the two market segments in the covered period of time (from 2015 to 2020) led to similar results that confirm the existence of a link: the sale market is characterized by an average standard deviation equal to 0.084, whereas the rental market has an average standard deviation equal to 0.069 and both have a negative trend. All the other variables show a low level of correlation, as also confirmed by the VIF.

5. Results

The stepwise regression method allows to define a clear mathematical relationship among the variables, characterized by a high statistical performance of the obtained model. The development of the stepwise regression approach took 5 steps and, after the removal of 12 outliers from the initial sample of the case study, a final model with the R^2 equal to 0.72 is obtained for 201 homogeneous market zones. Among

the initial sample of 12 explanatory variables, the model selects the following 5 explanatory variables as the real estate risk factors that most influence the residential capitalization rate for the city of Rome (Italy):

1) Per capita income (PCI).
2) Empty properties (EP).
3) Variation of residential sale values (VRS).
4) Variation of residential rental values (VRR).
5) Average residential sale time (ARST).

In Table 4, the statistical performance coefficient (R and R^2), the accuracy of predictions, the standard error of the estimate and the autocorrelation level analysis are reported:

Table 4

Summary of the regression steps and the related characterizing statistical parameters

STEP	R	R^2	ADJUSTED R^2	STANDARD ERROR OF THE ESTIMATE	DURBIN-WATSON
1	0.759	0.577	0.575	0.0041715	
2	0.805	0.648	0.644	0.0038153	
3	0.831	0.691	0.686	0.0035851	
4	0.843	0.711	0.705	0.0034713	
5	0.848	0.720	0.713	0.0034288	2.100
1. Predictors: (constant). PCI					
2. Predictors: (constant). PCI . EP					
3. Predictors: (constant). PCI . EP . VRR					
4. Predictors: (constant). PCI . EP . VRR . VRS					
5. Predictors: (constant). PCI . EP . VRR . VRS . ARST					

Source: own study.

The variables excluded by the final model are 7: i) average residential rental times (ARRT), ii) attractiveness level (AL), iii) property maintenance costs (MC), iv) households living in an owned apartment (PA), v) households living in a rented apartment (RA), vi) unemployment rate (UR), and vii) population density (PD).

The ANOVA test confirms that the 5 explanatory variables of the final model improve the interpretation of the phenomenon. The Durbin-Watson coefficient - for determining the autocorrelation of residuals – is equal to 2 and indicates that there is no autocorrelation. The Student's t test on the significance of the individual explanatory variables indicates that all the variables offer a significant contribution to the explanation of the capitalization rate. The F-Fisher test, performed at a confidence level of 95%, leads to the rejection of the hypothesis that the vector of the regression coefficients is zero. For all the explanatory variables, the observed p-value is lower than the theoretical one (<0.05) explaining a significant share of the variance of the capitalization rate. The standard error of the model is very good. The hypothesis of a normal distribution of errors is also tested. The regression equation specification error tests, which report any errors in the specification of the adopted function; the White test, relative to the absence of heteroskedasticity; and the Chow test, which verifies the existence of a structural break, have p-values higher than 0.05, confirming the reliability of the model. The values of the variance inflation factors (VIF) are all lower than 5, by verifying the absence of multicollinearity among the independent variables.

The Root-Mean-Square Error (RMSE) of 0.092 indicates an optimal fit of the regression model for the considered data. The Mean Absolute Percentage Error (MAPE) is good and equal to 0.068, therefore the average difference between the forecasted values and the actual values is about the 6.85%. The model prediction quality (goodness of fit) is determined through the Maximum Absolute Relative Error (MaxAPE) and is equal to 0.410, confirming the optimal quality of the regression. In order to verify the consistency of the results, a back forward stepwise regression has been developed and the obtained RMSE scores, which interpret the standard deviation of the unexplained variance, are compared. Since the lower value of RMSE indicates better fit of the model, the back forward stepwise regression, with a RMSE of 0.254, appears to have a optimal fit of the regression model for the considered sample of data compared to the RMSE equal to 0.092 of the applied forward stepwise regression.

The coefficients provided by the stepwise regression model that explains the significance level of each of the risk factors and the relationship between them and the capitalization rate are described in Table 5.

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Table 5

Coefficients of significance of the explanatory variables

MODEL	RISK FACTOR	EXPLANATORY VARIABLE	STAND. REGRESSION COEFFICIENTS	SIGN.
5		(Constant)		***
	Tenant	*PCI*	-0.715	***
	Location	*EP*	0.219	***
	Market	*VRR*	-0.376	***
		VRS	0.273	***
		ARST	0.096	**

Note: *** is for p < 0.01, ** is for p < 0.05.

Source: own study.

Among the 5 explanatory variables selected by the stepwise regression model, 3 out of 5, i.e. VRR, VRS and ARST, pertain to the market risk factors.. 1 out of 5 – PCI - represents the tenant risk factors, and 1 - EP - is related to the location. The regression coefficients indicate the contributions made by each variable to the capitalization rate.

According to the regression coefficients, the "Per capita income" (PCI) is the most significant variable (-0.715), followed by the variations of the residential sales and rental values (VRR and VRS) for the market risk factors, with respective values of -0.376 and 0.273. The fourth significant variable is the percentage of "Empty Properties" (EP), at 0.219, whereas the least significant one is represented by another market risk factor (ARST 0.096).

As can be seen, despite the greater number of selected variables relating to market risk factors, the greatest contribution to the capitalization rate is made by the PCI. According to the obtained results, the relationship existing between this variable and the capitalization rate is in fact negative: as the PCI level of the population living in the homogeneous market zones increases, the capitalization rate of the residential sector decreases. The reasons are to be found in what the PCI variable expresses, i.e. the level of the financial stability of the tenants, therefore a higher level of PCI implies greater financial stability and, therefore, a lower real estate risk, expressed in terms of a decrease in the capitalization rate.

The second significant variable - VRR – has an inverse relationship with the capitalization rate. In this case, the broader dynamics of the real estate market that involve housing demand should be considered. Several studies show that greater variations in rental values lead to an increase in housing demand based on the expectations of investors. Moreover, other studies demonstrate that exogenous shocks can have a positive influence on the housing demand of the real estate market, consequently by reducing the capitalization rates of income producing properties. Therefore, a positive relationship that supports the increase in housing demand, the change in rental values and the positive exogenous shocks, can be used to state that if the variations in rental values increase, a reduction in capitalization rates may correspond in the city of Rome (Büchler et al., 2021). The housing supply of the city of Rome in the period of time between 2015 and 2020 confirms the obtained results: it has considerably increased starting from 2014 and up to 2020 and beyond, making the residential real estate rental market in Rome, in absolute terms, one of the most dynamic and growing in Europe. The exogenous shock that can be considered for justifying this growth is the reduction of the mortgage rates from the 0.05 % to the 0.0 % between the 2015 and 2020, after the injection of financial liquidity established by the Central European Bank. This result is consistent with the study carried out by Sivitanides et al., (2001) where the analysis of the capitalization rate variations show that an increase of +10% of rental levels affects the capitalization rate of the apartments more than other factors.

The EP, VRS and ARST explanatory variables selected by the final model show a positive relationship with the residential capitalization rate of the city of Rome. This means that if the percentage of empty properties, the variation of the residential sales between the 2015 and 2020 and the average residential sales times increase, the capitalization rate also increases. This result is consistent with the empirical expectations because the three risk factors represented by the variables influence the local real estate market risk level in a negative way. In particular, the EP variable could represent the level of the urban quality of the homogeneous zone by considering the presence of empty properties associated with abandoned or underutilized real estate assets. It is quite clear that the presence of empty properties is often associated to several socio-economic and environmental diseases (Vallebueno and Lee, 2023; Tajani et al., 2022; Forouhar and Forouhar, 2020; Locurcio et al., 2020). Therefore, if it is found to increase, the urban quality is worsening and the risk level associated to the location's features is relevant. Under these conditions, the capitalization rate of residential income producing properties undergoes a positive variation expressing a greater risk in the homogeneous zones affected by EP increments.

The results of the relationships between the VRS variable and the capitalization rate are also consistent

with the empirical evidence. In fact, growing variations of residential sales values reduce sales market stability, and this implies a greater perception of risk leading to a higher residential capitalization rate. The positive relationship of the ARST variable on the capitalization rate can be justified by considering that if the number of months it takes to sell a residential property increases, it means that the dynamism of the real estate market of the homogeneous zones considered is low and therefore the perceived risk increases, influencing the capitalization rate. It consequently undergoes an increase to consider this risks' condition.

In order to easily and immediately verify the consistency of the obtained results, but especially allow the real estate investors to know the level of the investment risk related to the variation of capitalization rate of the residential sector of the city of Rome, the spatial distribution of the values of the 5 variables and the estimated capitalization rate for each of the 213 zones are represented in the following Figures: 1a, b, c, d, e and f.

As it is possible to see, the homogeneous real estate market zone where low levels of estimated residential capitalization rate can be observed (yellow in the city center) correspond to the highest levels of PCI and VRR. The peak values of the estimated dependent variable (deep orange) correspond to those real estate areas that are characterized by an elevated time on the market (ARST) and considerable variations of the residential sales prices and the presence of empty properties (VRS and EP).

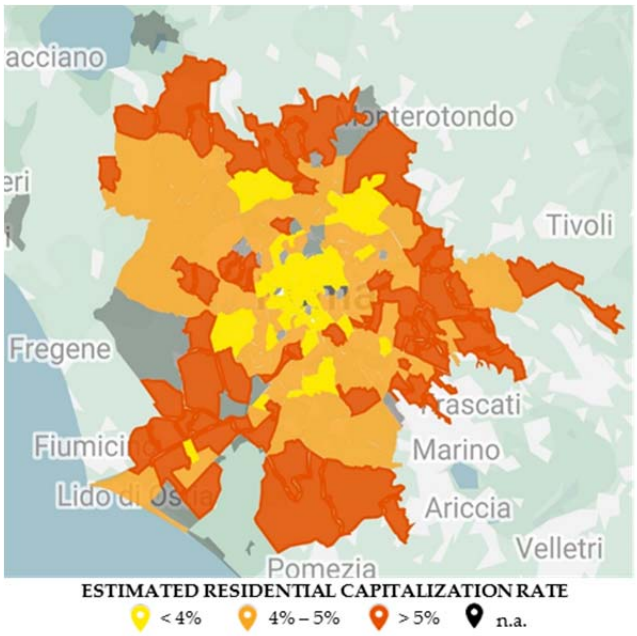

Figure 1a. Spatial distribution of the estimated capitalization rate. *Source*: own study.

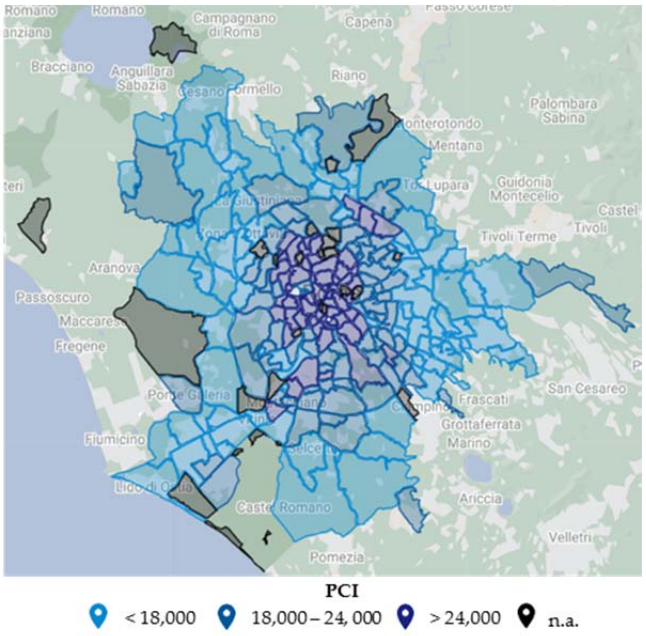

Figure 1b. Spatial distribution of the per capita income. *Source*: own study.

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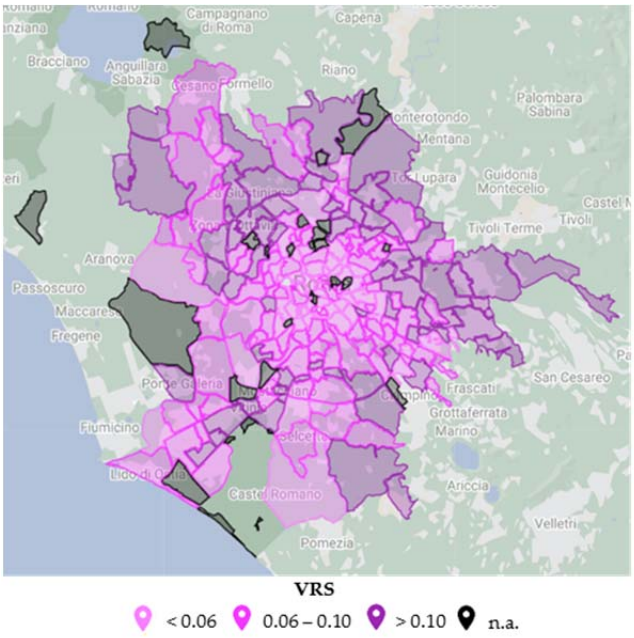

Figure 1c. Spatial distribution of the variation of the residential sales *Source*: own study.

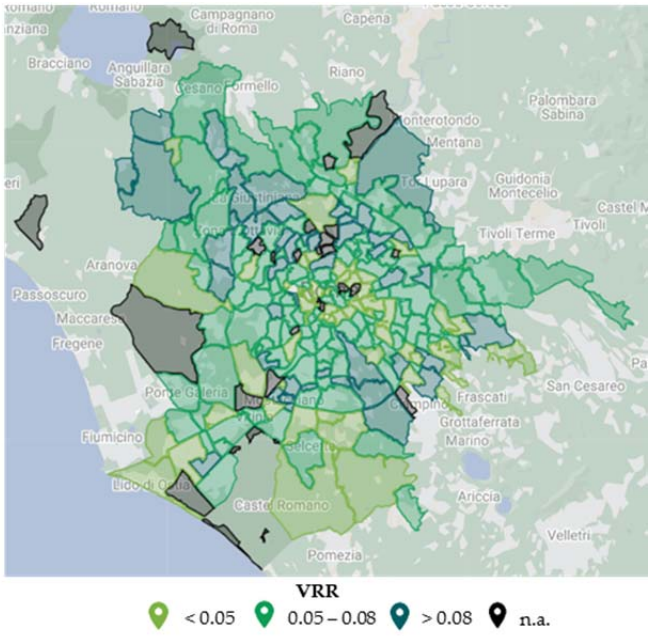

Figure 1d. Spatial distribution of the residential rental values *Source*: own study.

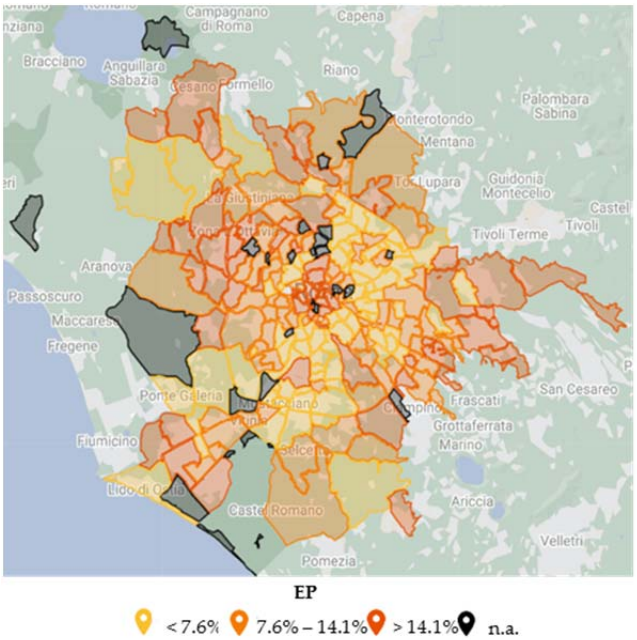

Figure 1e. Spatial distribution of the empty properties. *Source*: own study.

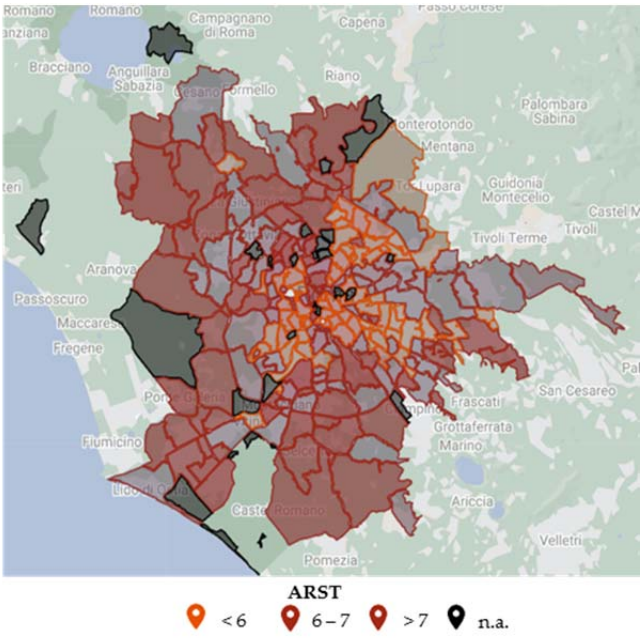

Figure 1f. Spatial distribution of the average residential sales times. *Source*: own study.

6. Conclusions

The assessment of income-producing properties has recently increased, since they represent the bulk of the existing housing asset. The main feature that characterizes this type of properties is their capacity to produce a stream of income, therefore the income approach is often considered for the determination of their market value. However, a critical issue regarding its application pertains to the choice of an adequate capitalization rate, which could significantly affect the assessment, and the determination of which can be susceptible to all those variables that also influence the net operating income and the market value (Morano et al., 2021).

The aim of the present research has been the identification of the local real estate risk factors that most affect the capitalization rate of the residential sector. The research aim has been pursued through

the development of a regressive-based methodological approach that consists of 4 phases. The obtained results have allowed for conclusive remarks: capitalization rate is extremely susceptible to variations of per capita income, the variable that has been chosen for representing tenant risk, and the variation of the rental values, expressing the market risk. For both of them, a negative relationship has been observed, demonstrating the decrease of the capitalization rate and, therefore, a decrease in the perceived real estate risk in correspondence to the growth of these two risk factors. For all the achieved results of the regression model, coherence with the empirical evidence has been verified. It is important to highlight that the sample relates to the city of Rome, and therefore the results also refer specifically to the characteristics and dynamics of its real estate market.

The practical implication of this methodological approach is the possibility to support valuers in determining the capitalization rate of the residential sector, knowing that a change in the real estate risk factors selected by the model may cause a change in the capitalization rate, according to the determined relationships. It contributes to describing and interpreting the capitalization rate determination of the residential sector at the sub-municipal scale in a clear and rigorous manner. Furthermore, a specific new value that the realized research brings at the national and international level is the possibility to classify investment risk according to the main factors selected by the model, in order to inform the investor about the areas that are more consistent with his risk appetite according to the possible changes of the selected variables (in this particular case study: per capita income, empty properties, variation of the residential sale and rental values and the average residential sales time) in a specific territorial context. The evaluation standards highlight the role of the capitalization rate as an indicator of the perceived investment risk in the real estate market.

The scientific contribution of the paper is related to the innovation of a procedure for the assessment of capitalization rate, which in the real estate sector represents the parameter characterized by the highest level of uncertainty. The filled gap in the literature regards the residential sector, especially in the Italian framework, which is little studied when given its importance within the field of real estate valuations of existing assets. Other filled gaps regard the scarce relevance attributed to the sub-municipal scale and the study of selected risk factors.

Future developments of the research could concern the expansion of the set of real estate risk factors by also considering other territorial scales, the application of this approach to other income-producing property types and the comparison of the achievable results that could derive from the application of other innovative regression techniques.

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References

Anelli, D., & Tajani, F. (2023). Spatial decision support systems for effective ex-ante risk evaluation: An innovative model for improving the real estate redevelopment processes. *Land Use Policy, 128*, 106595. https://doi.org/10.1016/j.landusepol.2023.106595

Austin, G. (2012). Sustainability and income-producing property valuation: North American status and recommended procedures. *Journal of Sustainable Real Estate, 4*(1), 78–122. https://doi.org/10.1080/10835547.2012.12091832

Bleich, D. (2003). The reaction of multifamily capitalization rates to natural disasters. *Journal of Real Estate Research, 25*(2), 133–144. https://doi.org/10.1080/10835547.2003.12091109

Chaney, A., & Hoesli, M. (2012). Transaction-based and appraisal-based capitalization rate determinants. *Swiss Finance Institute Research Paper*, 12-28.

Chaney, A., & Hoesli, M. (2015). Multifamily residential asset and space markets and linkages with the economy. *Journal of Property Research, 32*(1), 50–76. https://doi.org/10.1080/09599916.2014.913656

Chen, J., Hudson-Wilson, S., & Nordby, H. (2004). Real estate pricing: spreads & sensibilities: why real estate pricing is rational. *Journal of Real Estate Portfolio Management, 10*(1), 1–21. https://doi.org/10.1080/10835547.2004.12089692

Chervachidze, S., & Wheaton, W. (2013). What determined the great cap rate compression of 2000–2007, and the dramatic reversal during the 2008–2009 financial crisis? *The Journal of Real Estate Finance and Economics, 46*(2), 208–231. https://doi.org/10.1007/s11146-011-9334-z

Chichernea, D., Miller, N., Fisher, J., Sklarz, M., & White, B. (2008). A cross-sectional analysis of cap rates by MSA. *Journal of Real Estate Research, 30*(3), 249–292. https://doi.org/10.1080/10835547.2008.12091222

Chuangdumrongsomsuk, M., & Fuerst, F. (2017). Determinants of cap rates in US Office markets. *Journal of Real Estate Literature, 25*(2), 265–282. https://doi.org/10.1080/10835547.2017.12090458

Cui, F. (2020). Quantitative study on factors affecting the price of residential real estate multiple linear regression model. [IOP Publishing.]. *Journal of Physics: Conference Series, 1629*(1), 012071. https://doi.org/10.1088/1742-6596/1629/1/012071

d'Amato, M. (2010). A location value response surface model for mass appraising: An "iterative" location adjustment factor in Bari, Italy. *International Journal of Strategic Property Management, 14*(3), 231–244. https://doi.org/10.3846/ijspm.2010.17

eISSN: 2300-5289 | Received 2024-01-17 | Revised 2024-05-03 | Accepted 2024-05-14

d'Amato, M. (2015). Income approach and property market cycle. *International Journal of Strategic Property Management, 19*(3), 207–219. https://doi.org/10.3846/1648715X.2015.1048762

Desboulets, L. D. D. (2018). A review on variable selection in regression analysis. *Econometrics, 6*(4), 45. https://doi.org/10.3390/econometrics6040045

Devaney, S., Livingstone, N., McAllister, P., & Nanda, A. (2019). Capitalization rates and transaction activity in international office markets: A global perspective. *Global Finance Journal, 42*, 100469. https://doi.org/10.1016/j.gfj.2019.04.003

Elliehausen, G., & Nichols, J. B. (2012). *Determinants of capitalization rates for office properties*. Federal Reserve Board Working. Fiduciary Education.

Feng, G. (2015). Testing the dividend pricing hypothesis in housing markets: The role of risk.

Ferreira, F. A., Spahr, R. W., Sunderman, M. A., & Jalali, M. S. (2018). A prioritisation index for blight intervention strategies in residential real estate. *The Journal of the Operational Research Society, 69*(8), 1269–1285. https://doi.org/10.1080/01605682.2017.1390535

Fisher, G., Steiner, E., Titman, S., & Viswanathan, A. (2020). *How does property location influence investment risk and return*. Working Paper.

Forouhar, N., & Forouhar, A. (2020). Quality of life in neighbourhoods undergoing re-newal: Evidence from Mashhad, Iran. *Urbani Izziv, 31*(2), 101–113. https://doi.org/10.5379/urbani-izziv-en-2020-31-02-004

Gabrielli, L., & French, N. (2020). Pricing to market: Property valuation methods–a practical review. *Journal of Property Investment & Finance, 39*(5), 464-480. https://doi.org/10.1108/JPIF-09-2020-0101

Geltner, D. M., Miller, N. G., Clayton, J., & Eichholtz, P. (2007). *Commercial real estate*. Thomson Higher Education. Mason.

Jafari, A., & Akhavian, R. (2019). Driving forces for the US residential housing price: A predictive analysis. *Built Environment Project and Asset Management, 9*(4), 515–529. https://doi.org/10.1108/BEPAM-07-2018-0100

Larriva, M. (2022). Cap rates as a function of real economic growth. *Journal of Risk and Financial Management, 15*(8), 324. https://doi.org/10.3390/jrfm15080324

Letdin, M., Sirmans, G. S., Smersh, G. T., & Zhou, T. (2022). An analysis of the determinants of retail capitalization rates.

Letdin, M., Sirmans, G. S., Smersh, G., & Zhou, T. (2022). The role of tenant characteristics in retail cap rate variation. Available at *SSRN 4119899*. https://doi.org/10.2139/ssrn.4119899

Locurcio, M., Tajani, F., Morano, P., & Anelli, D. (2020). A multi-criteria decision analysis for the assessment of the real estate credit risks. In Appraisal and Valuation: Contemporary Issues and New Frontiers (pp. 327–337). Springer International Publishing.

Maghelal, P., Andrew, S., Arlikatti, S., & Jang, H. S. (2014). Assessing blight and its economic impacts: A case study of Dallas, TX. *WIT Transactions on Ecology and the Environment, 181*, 187–197. https://doi.org/10.2495/EID140161

Manganelli, B., Morano, P., & Tajani, F. (2014). Risk assessment in estimating the capitalization rate. *WSEAS Transactions on Business and Economics, 11*(1), 197–206.

McGrath, K. M. (2013). The effects of eco-certification on office properties: A cap rates-based analysis. *Journal of Property Research, 30*(4), 345–365. https://doi.org/10.1080/09599916.2012.762034

Morano, P., Tajani, F., & Anelli, D. (2021). Urban planning variants: A model for the division of the activated "plusvalue" between public and private subjects. *Valori e Valutazioni, 28*.

Napoli, G., Giuffrida, S., Trovato, M. R., & Valenti, A. (2017). Cap rate as the interpretative variable of the urban real estate capital asset: A comparison of different sub-market definitions in Palermo, Italy. *Buildings, 7*(4), 80. https://doi.org/10.3390/buildings7030080

Netzell, O. (2009). A study of micro-level variation in appraisal-based capitalisation rates. *Journal of Property Research, 26*(3), 235–263. https://doi.org/10.1080/09599911003669682

Oikarinen, E., & Falkenbach, H. (2017). Foreign investors' influence on the real estate market capitalization rate–evidence from a small open economy. *Applied Economics, 49*(32), 3141–3155. https://doi.org/10.1080/00036846.2016.1254343

Peng, L. (2013). *Finding cap rates: A property level analysis of commercial real estate pricing*. Department of Finance University of Colorado at Boulder Leeds School of Business.

Peyton, M. S. (2009). Capital markets impact on commercial real estate cap rates: A practitioner's view. *Journal of Portfolio Management, 35*(5), 38–49. https://doi.org/10.3905/JPM.2009.35.5.038

Phillips, R. S. (1988). Residential capitalization rates: Explaining intermetropolitan variation, 1974–1979. *Journal of Urban Economics, 23*(3), 278–290. https://doi.org/10.1016/0094-1190(88)90019-8

Pinto, A. M., Ferreira, F. A., Spahr, R. W., Sunderman, M. A., Govindan, K., & Meidutė-Kavaliauskienė, I. (2021). Analyzing blight impacts on urban areas: A multi-criteria approach. *Land Use Policy, 108*, 105661. https://doi.org/10.1016/j.landusepol.2021.105661

Pivo, G. (2010). Owner-tenant engagement in sustainable property investing. *Journal of Sustainable Real Estate, 2*(1), 184–199. https://doi.org/10.1080/10835547.2010.12091801

Prasetyanto, P. K., & Sasana, H. (2020). The capitalization rate of real estate property in Sleman District, Yogyakarta Province, Indonesia. *Jurnal Ekonomi Pembangunan: Kajian Masalah Ekonomi dan Pembangunan, 20*(2), 141-152.

Ranjan, P., & Mishra, S. (2021). Risk factors analysis for real estate price prediction using regression approach. In Cognitive Informatics and Soft Computing (pp. 61–72). Springer. https://doi.org/10.1007/978-981-16-1056-1_6

RICS (20222), *Global Standards 2022*. Published by Royal Institution of Chartered Surveyors.

Roulac, S. (1996). Real estate market cycles, transformation forces and structural change. *Journal of Real Estate Portfolio Management, 2*(1), 1–17. https://doi.org/10.1080/10835547.1996.12089519

Simons, R., Arbel, Y., Choi, E., & Shahar, D. B. (2011). Explaining the variation in residential capitalization rates worldwide: A preliminary investigation. *The ERES Journal*, 1-10

Sivitanides, P., Southard, J., Torto, R. G., & Wheaton, W. C. (2001). The determinants of appraisal-based capitalization rates. *Real Estate Finance, 18*(2), 27–38.

Sivitanidou, R., & Sivitanides, P. (1999). Office capitalization rates: Real estate and capital market influences. *The Journal of Real Estate Finance and Economics, 18*(3), 297–322. https://doi.org/10.1023/A:1007780917146

Tajani, F., Guarini, M. R., Sica, F., Ranieri, R., & Anelli, D. (2022). Multi-criteria analysis and sustainable accounting. defining indices of sustainability under Choquet's integral. *Sustainability (Basel), 14*(5), 2782. https://doi.org/10.3390/su14052782

Tajani, F., Morano, P., & Ntalianis, K. (2018). Automated valuation models for real estate portfolios: A method for the value updates of the property assets. *Journal of Property Investment & Finance, 36*, 324–347. https://doi.org/10.1108/JPIF-10-2017-0067

TEGOVA. (2020), *European Valuation Standards*. Available at: https://tegova.org/static/72fa037473e198cbd428e465158bcfdb/a6048c931cdc93_TEGOVA_EVS_2020_digital.pdf

Thibodeau, T. G., & Peng, L. (2012). Risk segmentation of American homes: Evidence from Denver. *Real Estate Economics*.Available at SSRN: https://ssrn.com/abstract=2061269

Tian, C. Y. (2013). Are capitalization rates really constant within housing markets? Available at *SSRN 2282780*. https://doi.org/10.2139/ssrn.2282780

Unbehaun, F., & Fuerst, F. (2018). Cap rates and risk: A spatial analysis of commercial real estate. *Studies in Economics and Finance, 35*, 25–43. https://doi.org/10.1108/SEF-11-2016-0267

Vallebueno, A., & Lee, Y. S. (2023). Measuring urban quality and change through the detection of physical attributes of decay. *Scientific Reports, 13*(1), 17316. https://doi.org/10.1038/s41598-023-44551-3 PMID:37828136

Yilmazer, S., & Kocaman, S. (2020). A mass appraisal assessment study using machine learning based on multiple regression and random forest. *Land Use Policy, 99*, 104889. https://doi.org/10.1016/j.landusepol.2020.104889

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