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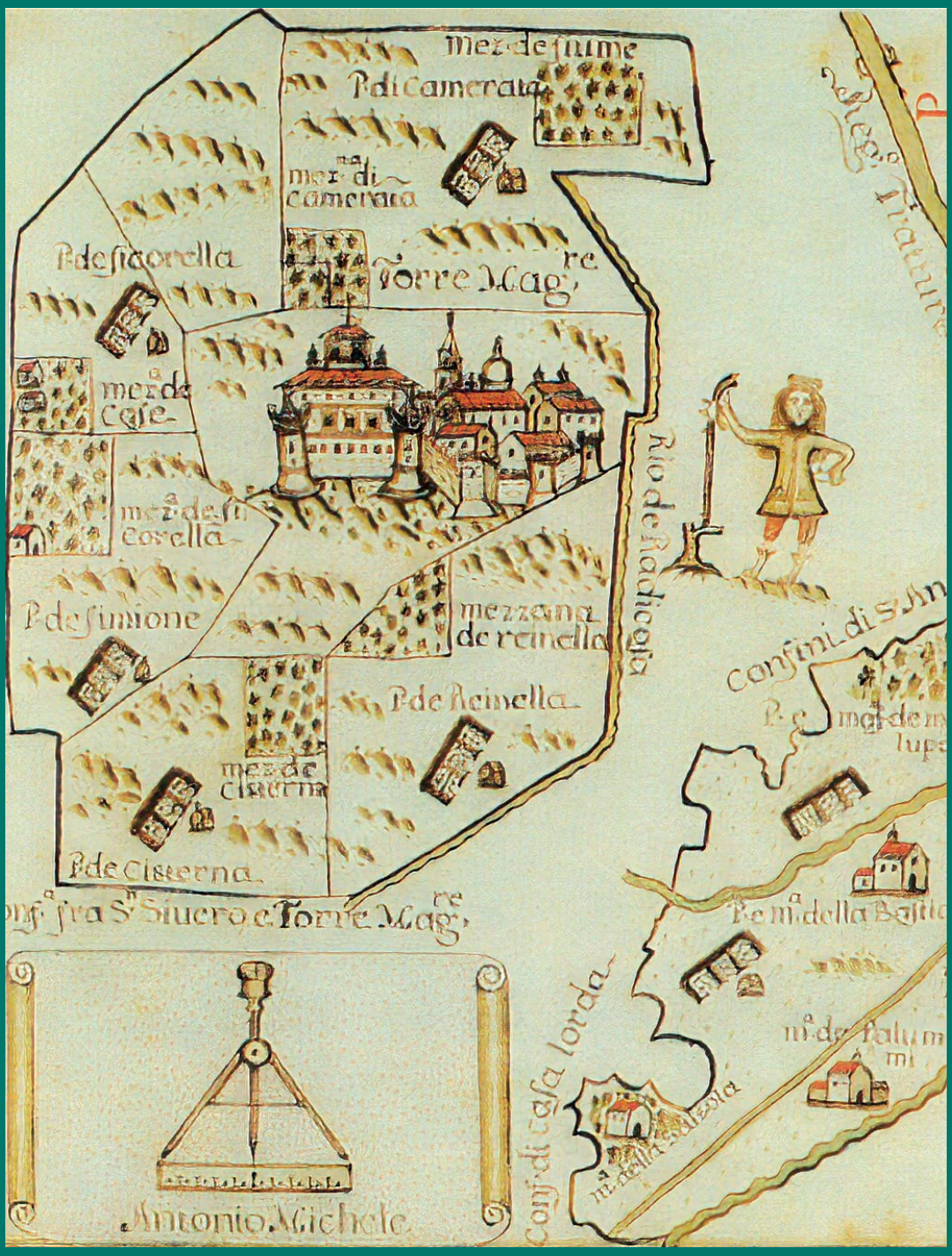

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Simultaneous evaluation of dairy farmers' behaviour and intention to adopt technological devices

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Abstract. Society's awareness of livestock production conditions has increased interest in animal welfare (AW), prompting farmers to consider it in their strategies. However, the adoption of digital devices and sensors to ensure AW is still relatively low. The aim of this study was to assess simultaneously the stated behaviour and intention of dairy farmers towards adopting technological tools for AW. The extended Theory of Planned Behaviour (e-TPB) was selected as theoretical base. It is "extended" since new predictors are integrated in the standard framework of the TPB. The research questions were addressed using a partial least squares structural equation modelling. The findings suggest the existence of a gap between farmers' intentions and behaviour. Perceived Behavioural Control plays a significant role in behaviour, indicating the predominant influence of self-confidence in farmers' choices. Operating margin and technological specialization of the farms are significant predictors of farmers' behavior.

Keywords: Animal welfare, Precision Livestock Farming, Dairy cattle, PLS-SEM, Theory of Planned Behaviour.
JEL codes: D22, D80, D91.

1. INTRODUCTION

Nowadays, dairy farmers face several economic, ecological, and social challenges, including increasing public awareness of animal welfare issues (Borges et al., 2019; Guyomard et al., 2021; Meuwissen et al., 2019; Sekyere et al., 2021; Temple and Manteca, 2020). Farmers' choices are influenced by the new demands of consumers who pay increasing attention to animal welfare conditions, to the point that they are pushing farmers to consider them in their business strategies (Alonso et al., 2020; Blanc et al., 2020; Tullo et al., 2019). As a result, it has proven crucial for livestock farmers to take measures that can improve the quality of life of farm animals (Silva et al., 2021) in order to ensure high production standards.

Exacerbating these ethical concerns is the context of a growing population, estimated to reach 9.8 billion by 2050 (Zarbà et al., 2022), which will imply a significant increase in the demand for food products of animal origin. To meet the growing demand, the related production would have to expand and so would the number of animals, with negative effects on livestock management (Tekin et al., 2021) as well as environmental consequences from increased greenhouse gas emissions causing depletion of the atmosphere.

The scientific literature suggests that technological innovations can help farmers improve their income and farm efficiency (Chavas and Nauges, 2020; Jukan et al., 2017). However, farmers face a complex production reality that significantly affects their business choices.

Tools that can be used to improve the efficiency of livestock farms including in terms of animal welfare include pedometers and collars (Gòmez et al., 2021; Poulopoulou et al., 2019). However, other tools when adopted may improve animal welfare and satisfy the five freedoms of animals[1], making it difficult to choose the most appropriate one (Chapa et al., 2020).

Detecting the physical status of individual animals can prevent disease outbreaks, and consequently save veterinary costs and ensure healthy livestock with better production performance, as well as ensure high welfare standards (Stevenson, 2023; Tekin et al., 2021).

Moreover, the adoption of specific animal welfare devices implies beneficial environmental outputs (Fraser, 2008). In fact, the management of livestock management may help in reducing greenhouse emission (Stygar et al., 2021; Niloofar 2021), for instance, by monitoring the use of water (Morrone et al., 2022; Neethirajan and Kemp, 2021), by ameliorating manure management, by reducing the generation of enteric gas, feeding the animal with better quality products (Bianchi et al., 2022) and consequently changing the habit of feeding livestock with merely locally available grown forages or less valuable agricultural by-products (Gonzali, 2020; Nadal-Roig et al., 2019). Next, livestock wastewater contains large amounts of mineral and organic compounds and in absence of a specific management system they can accumulate in soil and water can provoke serious environmental pollution (Licata et al., 2021).

Overall, animal welfare tools are important for the so-called Precision livestock farming (PLF) technologies which according to Berckmans (2017) is the continuous management of individual animals in real-time monitoring relevant events such as health, welfare, production/reproduction, and environmental impact using information and communication technologies (ICT). PLF constitutes a great support for farmers to accomplish three aspects: welfare (Krampe et al., 2021, Tobin et al., 2022) economic efficiency and health (Stachowicz et al., 2021; Veissier et al., 2019) and environment (Guarino et al., 2017).

Therefore, PLFs are animal-centered tools that can support farmers in herd management decision making (Lovarelli et al., 2020; Simitzis, 2022). PLF tools indicate precise useful information about livestock, and in the event that these indications reveal anomalies, the farmer can take action by choosing new strategies to adopt (Norton and Berckmans, 2017) to maintain the level of animal welfare (Rowe et al., 2019).

In addition, animal welfare devices are part of that category of technology called the Internet of Things (IoT) (Akbar et al., 2020; Akhigbe et al., 2021; Zhang et al., 2021) whose potential is very useful for monitoring animal health (Banhazi et al., 2012). When put in communication with other technological devices, IoT systems act completely autonomously, such as sending a message to the veterinarian in real time (Aquilani et al., 2022), responding to a request for information, automatically activating air conditioning or fans if the animals' body temperature rises. All sensed data are also transmitted and stored in farmers' computers. Each farmer can interpret each piece of information, identify any critical issues and take timely action (Lovarelli et al., 2022; Schillings et al., 2021).

Focusing on dairy animals, there are many PLFs useful for monitoring animal welfare (da Borso et al. 2022; Henchion, 2022). Some of the available technologies can be placed on or in the cow (Stone, 2020) and might be wearable or remote equipment for recording physiological or behavioral parameters (Herlin et al., 2021). Among these devices, there are pedometers, i.e., sensors that, when placed on dairy cows, allow them to monitor the behavior of individual animals. In fact, pedometers function as accelerometers (Mattachini et al., 2013; Stygar, 2021), or measure temperature, movements, digestive activities and panting from heat stress (Ramón-Moragues et al., 2021). In detail, pedometers predict lameness earlier than the appearance of the clinical signs (Mazrier, 2006); detect oestrus periods (Roelof et al., 2005); record locomotion behaviors, the lying and standing time (Mensching et al., 2021; Santo et al., 2020; Shepley et al., 2017; Vasseur, 2017), the frequency of lying (Shepley et al., 2020), the number of lying bouts

[1] Their formulation dates back in the early 1990s and they synthetize society's expectations for the conditions animals should experience when under human control: 1) Freedom from thirst, hunger and malnutrition; 2) Freedom from discomfort and exposure; 3) Freedom from pain, injury, and disease; 4) Freedom from fear and distress; 5) Freedom to express normal behaviour.

and steps, the motion index at a resolution of 1 min (Stachowicz et al., 2022), etc.

With regard to the determinants influencing the use of modern technologies, numerous aspects have emerged in the scientific literature. One aspect is that the breeder's decision to invest in technological devices depends on their propensity to use the technology, their level of awareness of technologies and their capabilities (Makinde et al., 2022), especially if its use opens up new opportunities to improve the livestock' living conditions and a sustainable production (Hartung et al., 2017). Another reason to invest in digital systems turns out to be an improvement in profitability (Rutten et al., 2013; Steeneveld and Hogeveen, 2014) through the use of technology.

Moreover, among the variables that condition the adoption of digital tools in the agribusiness sector there are the operating revenues (Vázquez et al., 2019) and costs of the devices (Makinde et al., 2022).

The type of farm management also seems to have an impact on the intention to install the technology, with some farmers believing that PLF can better support pasture-based systems (Groher et al., 2020; Lomax et al., 2019), while others value their use in the barn as well (Umega and Raja, 2017).

Device's adoption also appears to be influenced by socio demographic aspects, including age, geographic location, education level (Groher et al., 2020; Pierpaoli et al., 2013) as well as attitudes towards animal welfare (Kellert, 1980; Richards et al., 2013).

Given the above, although the use of technology in agriculture and specifically in livestock management results are well recognized, existing technologies for PLF are underutilized. Hence, the present research aims at investigating the perception of dairy farmers about the importance of technology in livestock management and PLF in particular, on the one hand, to update the important research carried out by previous studies (Abeni et al., 2019; Rutten et al., 2013) and, on the other hand, to enrich the scientific literature by proposing a survey based on an hoc questionnaire and carried-out in the province of Ragusa, in Sicily.

It's worth noting that there are numerous regions worldwide known for their milk production, and the choice of a representative study area may depend on the specific focus or research interest within the field of milk production. The Hyblean region, located in the South-Eastern province of Ragusa is known for its agricultural activities, including livestock farming and it is the major milk-producing region in Sicily (Italy) (Ferguson et al., 2007; Pugliese et al., 2021). In 2022, milk deliveries in Sicily amounted to 191.675 tons of which 80.51% (154.314 tons) came from the province of Ragusa (CLAL, 2022).

According to the data reported in the "Statistics" section of the National Veterinary Information System, there were 633 dairy cattle farms in the Sicily region with 44,202 head raised at the end of 2022. Among them, 51 percent (323 farms) are in the province of Ragusa and concern the breeding of more than 30,200 heads (68.32%).

Despite all the barriers already emerged from previous studies in the literature about the adoption of animal welfare devices, to the best of our knowledge, the analysis of dairy farmers' intentions to use such devices is lacking. This is a preparatory aspect to understand the stated behaviour and the motivation associated with the adoption of a certain behaviour.

Considering that intentions and stated behaviours are distinct phases determined by different factors, the present work aims to fill the gap regarding the analysis of their respective determinants. Specifically, we aim to investigate the adoption intentions of dairy farmers by taking into consideration both their individual opinions linked to the decisions, social environment influences and self-perceptions of personal capabilities and limitations. Subsequently, the analysis also regards farmers' behaviour, also using variables already known in literature but evaluated in a broader research context consisting in a simultaneous analysis of intentions and behaviour.

For this purpose, the Theory of Planned Behaviour (TPB) was used as a tool equipped with scientifically recognized constructs for measuring intentions and stated behaviours, in order to check for any correlation between them.

1.1. Objective and research questions

The general objective of the paper is to evaluate what drives dairy farmers toward the adoption of technological devices that can be used to improve firms' performances and animal welfare, by assessing both, stated behaviour and farmers' intention. To reach this goal several drivers of choices were selected. In particular, to properly assess stated behaviour and intention, the Theory of Planned Behaviour was selected as theoretical base by including the related psychological constructs: Intention, Subjective Norms, Perceived behavioural control and Attitude. Moreover, other variables were integrated in the model, related to socio-demographic characteristics of dairy farmers and firms' characteristics. For this motivation, the model adopted lies on the extended Theory of Planned Behaviour since new predictors are integrated in the standard framework of the TPB. Based on these considerations, the general objective can be deeply explored trough the following research questions:

1) Can the Attitude, Social Norms and Perceived Behavioural Control affect dairy farmers intention to adopt technological tools?
2) Can the Perceived Behavioural Control and intention affect dairy farmers' behaviour?
3) Can the socio-demographic characteristics of dairy farmers and firms' characteristics influence the stated behaviour?

The research questions were addressed using a multivariate statistical tool such as partial least squares structural equation modelling (PLS-SEM).

The paper is divided in different sections as follow: theoretical framework where the Theory of Planned Behaviour is deeply explained; methodology that includes information related to data collection and statistical modelling; results; discussion; conclusion where a brief sum of the outcome, implication, limitation and future research are included.

2. THEORETICAL FRAMEWORK

In this complex system, considering dairy farmers only as profit maximisers can be reductive and decrease the capacity to detect factors influencing behavioural changes (Despotović et al., 2019). Literature has provided several tools to improve the Attitudes (ATT), Social Norms (SN) and Perceived Behavioural Control (PBC) ability to describe producer behaviour using validated multi-items scales, such as the Theory of Planned Behaviour (TPB) (Despotović et al., 2019; Pienak et al., 2010; Rezaei et al., 2019). TPB was firstly formalized by Ajzen, (1991) that indicated that human behaviour can be conditioned by intention (INT). Intention can also be affected by three other constructs, as illustrated in Figure 1.

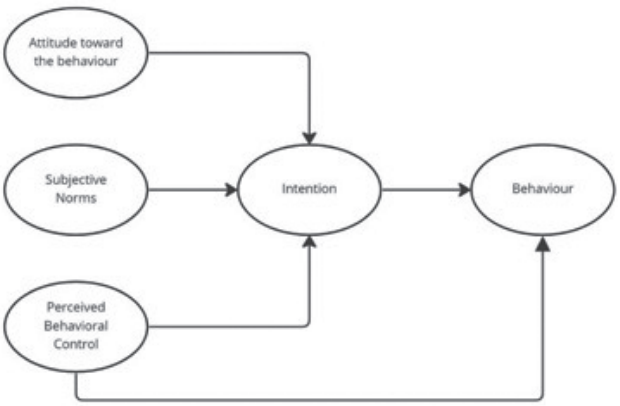

Figure 1. Theory of planned behavior by Aizen (1991).

The constructs individuated by Aizen have different meanings and are built using different items that are processed to find latent variables that describe their underlying information, which can be used as either dependent or independent variables through multivariate models (Raimondo et al., 2022). In particular, intention can be considered as the motivation associated with the adoption of a certain behaviour, a concept also related to the probability of performing it (Dorce, 2021; Raimondo et al., 2022). Attitudes group personal judgments and opinions that can be positive or negative toward a specific behavior, and can lead to the consequences of decisions (Kureshi and Sujo, 2019). Subjective norms include statements that link the influence of the social context and how it can affect the behaviour; while, perceived behavioural control represents a self-assessment of individual's capabilities and limitations that could affect the evaluated behaviour and the engagement in a particular activity (Lopez-Mosquera, 2016; Spina et al., 2023; Wauters et al., 2010). In particular, perceived control refers to the ease or difficulty of performing a particular behavior (Zhong et al., 2015).

TPB was adopted in different studies, to evaluate consumers behaviour related to several aspects such as organic products (Loera et al., 2022), honey and chicken consumption (Menozzi et al., 2015) or toward Protected Designation of Origin Certification (Menozzi, 2021). This theory was also applied to describe dairy farmers' behaviour. Borges and Lansik (2016) evaluated farmers' intention to improve natural grassland, finding that the intention of farmer was mainly moved by the perception of social pressure. In 2020 Savari and Gharechaee found that PBC, SN and ATT had a positive effect toward farmers' intention to for the safe use of chemical fertilizers. However, TPB can also be integrated with other constructs or items to enhance the capability of the model to describe human behaviour. In this case, authors indicate this strategy as Extended Theory of Planned Behaviour (Raimondo et al., 2022; Rezai et al., 2019). Indeed, in the present paper, different aspects were integrated to the standard constructs of TPB. In particular, to detect which factors can affect dairy farmers' behaviour toward the adoption of technological devices related to animal welfare, the following variables were used: Age, Education, Breeding type, the operating margin and the access to the Veterinary system. Based on these integrations on the standard TPB, the underlying theoretical base can be considered the extended TPB.

3. MATERIALS AND METHODS

3.1. Data collection

Data were collected in Sicily, specifically in Ragusa Province using a multi-section questionnaire during the last months of 2022 and early 2023 with face-to-face interviews. The province of Ragusa was chosen as the sampling area because of the high amount of milk produced and the high specialization of the farms, which have high investment capital and technical expertises. Consequently, this Province can be considered a representative area of intensive dairy farming (CLAL, 2022). To improve the reliability of the responses, the survey was administered by a trained interviewer with expertise in livestock farming and able to speak appropriately with dairy farmers.

Before the administration of the survey, a preliminary focus group was conducted with various experts in the field of cattle farming, such as dairy farmers, agronomist, public administration representant and academics. The focus group was conducted by 2 facilitators and was developed according to the question approach. This method allows to maximize the consistency of data collection and is structured in different as follow: opening questions, introductory questions, transition questions, key questions and final questions (Ruff et al., 2005). Several issues emerged such as the difficulty for entrepreneurs to obtain adequate remuneration, the lack of funds for structural investment, the need to improve the efficiency of the production system and supply chain, and new demands from consumers that include animal welfare.

These considerations were used to build the survey that was divided in four sections: Attitude toward investments in technological tools, characteristics of firms, attitude toward animal welfare that included TPB and finally socio-demographic feature of respondents. To collect data several questions were developed using both binary questions (yes or not) or in Likert scale from 1 to 5 were 1 means "I do not agree" and 5 "I agree". The last preliminary step was a pilot survey that was necessary to test the understanding level of the questions and subsequently to perform minor revision of the survey. Concerning the TPB part, the items for the constructs, included in the theory were adapted by other studies conducted on farmers' intention and behaviour (Despotović et al., 2019; Rezaei et al., 2019) and are shown in Table 1.

The latent constructs, ATT, SN, PBC and INT were measured by means of Likert scales from 1 to 5 where 1 = do not agree and 5 = agree and were built over 12 items, 3 for each construct. The stated behaviour was obtained from the first section of the survey. In particular, dairy farmers were asked if they employed 3 different technological devices that can also be used to improve the animal welfare. In particular we investigated collars, pedometers and video monitoring systems. A total of 117 dairy farmers adopted at least one of the tools investigated, then the dependent variables for the PLS-SEM, or the stated behaviour, was obtained by summing the positive answers related to the adoption of these instruments. The relations among variables are graphically reported in Figure 2.

The number of dairy farmers surveyed represents 36.22% of the total population in the province of Ragu-

Table 1. List of constructs and items derived from TPB for latent variable extrapolation.

Constructs	Mean (SD)	Items	References
ATT_1	4.863 (0.369)	Adopting animal welfare practices in my farm would lead to productive benefits	Despotović *et al.*, 2019; Pienak *et al.*, 2010 Raimondo *et al.*, 2022 Rezaei *et al.*, 2019
ATT_2	4.880 (0.351)	Adopting welfare practices would improve animal performances	
ATT_3	4.915 (0.337)	Adopting animal welfare practices can lead to professional satisfaction	
SN_1	4.932 (0.253)	People whose professional opinion I value support the introduction of animal welfare practices	
SN_2	4.923 (0.268)	People whose professional opinion I value suggest the introduction of animal welfare practices	
SN_3	3.692 (1.192)	I believe the community influences the choice of farmers to introduce animal welfare practices	
PBC_1	3.188 (1.192)	I have adequate funds and time to adopt animal welfare practices	
PBC_2	4.111 (1.007)	I can properly manage practices to improve animal welfare on the farm	
PBC_3	4.573 (0.634)	I have the technical knowledge and experience to adopt animal welfare practices	
INT_1	4.333 (0.991)	I am planning to adopt animal welfare practices this year	
INT_2	4.385 (1.024)	I plan to raise the level of animal welfare in the next 5 years	
INT_3	4.350 (1.003)	I plan to regularly increase animal welfare practices.	

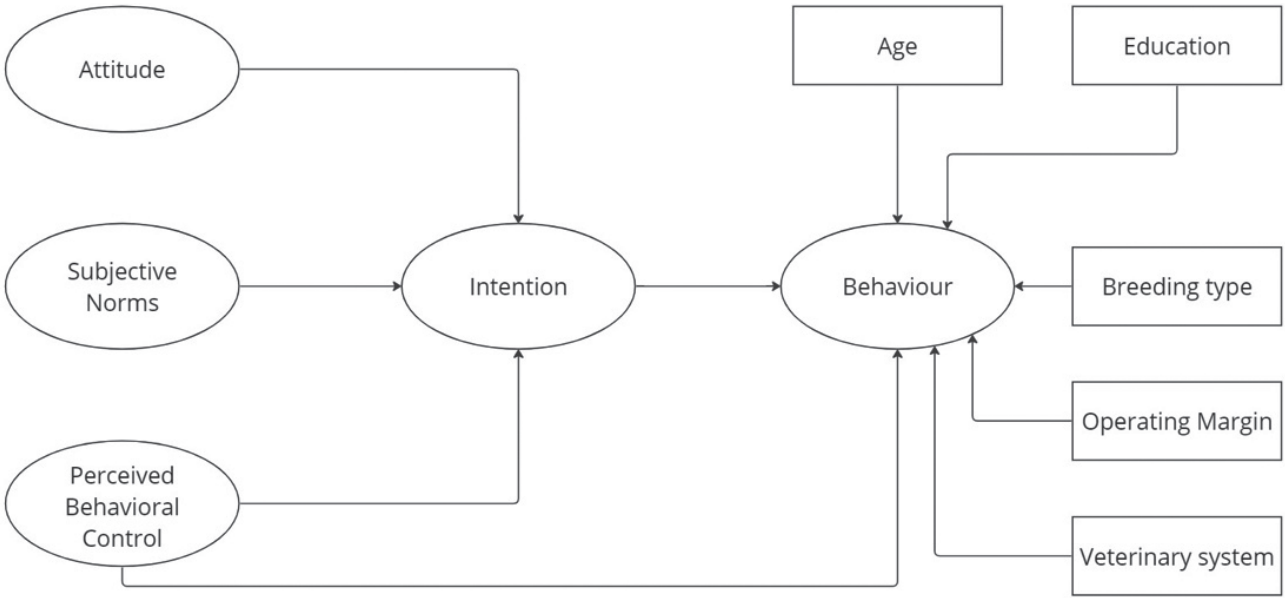

Figure 2. Graphical representations of the relations tested with the structural model.

sa. Based on the power sampling method suggested by Bartlett et al. (2001), the sample size for a population of 400 individuals considering an alpha value of 0.05 is 92. Therefore, the estimates of the models have been considered reliable and adoptable for the general population of Dairy farmers in the study area.

Data collection resulted in 117 valid surveys that were preliminary checked in the data cleaning process to assess the reliability of the answers. To deal with the research questions, some socio-demographic variables and firm characteristics were selected whose descriptive statistics are included in Table 2. These variables were adopted in the PLS-SEM model to get information related to the effect on dairy farmers' behaviour based on farmers and firms' characteristics. Among the variables used to enhance the descriptive capability of TPB, Age and Operating Margin were collected as continuous variables. Education and Breeding type were collected as categorical variables using three levels while the access of farmers at the Veterinary system as a dummy variable where 1 = yes.

Some further explanation is provided to fully understand the meaning of Veterinary system predictors. Indeed, Italian famers can have IT tools to access Italian veterinary services. If farmers can use these systems on the farm, it means that there is also a relationship with the attitude toward the use of computer systems for animal care. Consequently, this variable was adopted in the PLS-SEM model as integration of TPB constructs

3.2. Data Analysis

To address the research question, PLS-SEM was deemed as the most suitable multivariate statistical tool. The method is widely used in social sciences (Ringle et al., 2020) and is considered a useful approach when complex relationships between observed and latent variables are analysed (Sarstedt et al., 2022). Indeed, PLS-SEM is suitable for the analysis of constructs derived by validated scales, such as TPB, to evaluate implications from the adoption of theoretical theories in different case studies (Hair et al., 2019). Moreover, this multivariate method is more suitable than maximum likelihood estimators with covariance-based structural equation modeling (COV-SEM) when the structural model is complex and includes different constructs or whit limited sample size (Hair et al., 2019; Venturini and Mehmetoglu, 2019). Another important advantage in using PLS-SEM is related to the absence of distributional assumptions, such as data normality that rarely occur in social sciences (Hair et al., 2019; do Valle and Assaker, 2016). In fact, maximum likelihood estimators are less robust than PLS-SEM and could lead to abnormal results when normality is not meet (Reinartz et al., 2009). Finally, partial least squares result in higher statistical power, higher robustness, minimization of unexplained variance by maximize r square values and allows the implementation of both, constructs and single item variables (Hair et la., 2020)

PLS-SEM compute partial regressions relations in measurement and structural models by preforming dis-

Table 2. Descriptive statistics of the sample (n = 117).

Variables	Items	Coding	Frequency	Percent	Mean (SD)
Age	Age	Continuos			45.13 (13.13)
Education	Middle school or lower education	1	53	43.30	
	High School	2	47	40.17	
	University degree	3	17	14.53	
Breeding type	Cubicles for cattle	1	12	10.26	
	Permanent litter	2	94	80.34	
	Mixed	3	11	9.40	
Operating Margin	Operating Margin (€)	Continuos			16,696 (150,742)
Veterinary system	Yes	1	55	47.01	
	No	0	62	52.99	

tinct least square regression (Hair et al., 2019; Sarstedt et al., 2020). Indeed, this method is divided in measurement model that provides relations among latent variables derived by constructs and structural model. The second one, highlights the relationships among latent variables by adopting them as predictors (exogenous variables) and outcome variables (endogenous variables) (Venturini and Mehmetoglu, 2019). Constructs adopted for the analysis are considered as proxy of latent variables that are determined as linear combinations. Moreover, can be adopted for predictive purposes (Hair et al., 2020). The algorithm of PLS-SEM consists in three different parts: Iterative estimation of latent variable scores; Estimation of measurement model parameters, Estimation of structural model parameters (path coefficients) (Venturini and Mehmetoglu, 2019).

To assess goodness of fit, several indicators are used in this study. To assess the internal consistency of the construct, Cronbach alpha and Rho A were adopted whose values should be higher than 0.6 (Bland and Altman, 1997). Convergent validity was evaluated using average variance extracted (AVE) and the threshold for acceptability was 0.5. Collinearity among variables and constructs was calculated using the variance inflation factor (VIF) of which, the maximum value to consider collinearity acceptable would be 5. Finally, where the VIF values are acceptable, the variance explained by the different constructs was assessed by means of the r square value. This index is considered also as an estimation of the explanatory and predictive power of the model and was considered acceptable for value higher than 0.25 (Hair et al., 2019). Finally, the interpretation of standardized loadings was conducted for those whit value higher than 0.4 (Hair et al., 2011).

All the analyses were carried out using STATA software 17 and "plssem" package (Venturini and Mehmetoglu, 2019).

4. RESULTS

As indicated in methodology, different outcomes are provided by PLS-SEM analysis. Starting from the measurement model depicted in Table 3, the standardize loadings meet the criteria indicated by Hair et at., 2011, being higher than 0.4 except for SN3 that obtained a score of 0.374. However, since the reliability of the SN construct is high based on the alpha, rho and AVE values, the items was considered suitable to be included in the measurement model. This result indicate that all the items investigate in constructs provide a good contribution in the latent variables identified by the measurement model. This value can be interpreted as correlation between items and each related construct. The reliability of the factors was evaluated in different ways. In term of reliability, Cronbach's alpha values are higher than 0.6 for each latent variables indicating high internal consistency of the constructs. However, as indicated in literature, this indicator provides conservative value of internal consistency. Therefore, Rho A can complete the information being this coefficient more balanced than the first one (Hair et al., 2019). The values of Rho A are higher than 0.6 suggesting that each construct have adequate consistency and can be used in the structural model. Convergent validity was evaluated trough AVE that is higher than 0.5 for each construct, indicating the possibility for the latent variables to be used in the structural model.

The structural model followed the measurement one. However, the collinearity was tested using VIF analysis using each construct and items adopted in the structural model. The results of the collinearity test are shown in Table 4 and suggest that this issue does not affect the analysis and the variables are adequate for the analysis being the values of VIF lower than 5.

Moving on the structural analysis, the relations are tabulated in Table 5. The average r square obtained is

Table 3. Factor loadings and goodness of fit for the measurement model.

Items\Construct	Attitude	Subjective Norms	PBC	Intentions
ATT_1	0.648			
ATT_2	0.960			
ATT_3	0.647			
SN_1		0.929		
SN_2		0.924		
SN_3		0.374		
PBC_1			0.789	
PBC_2			0.872	
PBC_3			0.610	
INT_1				0.857
INT_2				0.927
INT_3				0.943
Cronbach alpha	*0.690*	*0.606*	*0.643*	*0.895*
rho_A	*1.240*	*0.689*	*0.696*	*0.895*
AVE	*0.587*	*0.619*	*0.584*	*0.827*

Table 4. VIF analysis for the constructs and items used in the structural model.

Constructs	Intentions	Stated-Behavior
ATT	1.146	
SN	1.176	
PBC	1.087	1.531
INT		1.708
Variables		
Age		1.486
Education		1.395
Breeding type		1.110
Operating Margin		1.162
Veterinary system		1.117

0.306, suggesting that the model that explanatory and predictive power of the analysis is sufficient. Path coefficients are indicative of the direction and the magnitude of the relations among Constructs and variables with the explained variables: Intention and stated-behaviour.

Starting with the relation with the intentions and TPB constructs, we found that only PBC has significant effect on dairy farmers' intention to adopt technological tools to improve animal welfare. Conversely, ATT and SN are not significant in the structural model. Since these latent variables are obtained starting from TPB adapted for the analysis of dairy farmers' intention and behaviour toward innovative tools, further explanations are provided.

Table 5. Structural model with path coefficients.

Constructs	Intentions	Stated-Behaviour
ATT	0.008 (0.922)	
SN	0.037 (0.661)	
PBC	0.559 (0.000)	0.211 (0.037)
INT		0.008 (0.945)
Variables		
Age		0.058 (0.558)
Education		0.065 (0.496)
Breeding type		-0.168 (0.052)
Operating Margin		0.380 (0.000)
Veterinary system		0.178 (0.040)

Note: p-values in parenthesis.

Another important information is provided by the coefficient related to ATT which is representative of dairy farmers' evaluation of the consequences of their decision. Being the coefficient close to zero, this construct seems to be unrelated with the intention. .

The structural model evaluated also the relations between TPB construct and items with dairy farmers' stated behaviour. Important outcomes are obtained by this model; in fact, INT is not significant. This result is particularly important because it indicates that there is an important gap between dairy farmers' intentions compared to the actual execution of the behaviour. PBC, on the other hand, is significant compared to the actual behaviour.

Since ATT 1 is not significant, it's also possible that the drivers of the stated behaviour lie on other aspects. So, as suggested by Spina et al. (2023), other aspects were considered in the structural models to improve researchers' ability to describe farmers behaviour. So, to get more information related to the drivers of the stated behaviour, single items variables related to farmers and firms' characteristics were included in the model. Among such predictors, Age, Education, Breeding type, Operating Margin and Veterinary system were integrated in the structural model and were found to be useful to describe dairy farmers' behaviour. In particular, Operating Margins represents the variable with the highest magnitude based on the obtained coefficient. Even if the p-value is just above the 0.05 limit, also breeding type indicates that producers that use Cubicles for cattle are more likely to adopt tools related to animal welfare. The access to the Veterinary system is positively related to the stated behaviour.

Finally, the results highlight neither age nor education is significant in the structural model, suggesting that the aspects that drive dairy farmers' choices are mostly related to the farms features rather than personal characteristics, except for self-awareness mediated by PBC.

5. DISCUSSION

The results about the significant effect of PBC on dairy farmers' intention to adopt technological tools to improve AW suggest the important role of dairy farmers' awareness in their capabilities described by this construct (Lima et al., 2018). The coefficient of PBC is positive, indicating that as self-awareness increases, intention toward the adoption of technological instruments increases (Timpanaro et al., 2023). Conversely, SN that consist in the effect of the system surrounding farmer, is not significant in predicting their intention. This result suggests that dairy farmers are little influenced by outside opinions, preferring to rely on their own knowledge in making managerial decisions (Bagheri and Teymouri, 2022; Dong et al., 2023).

Another important result is the construct ATT that seems to be unrelated with the intention. This result could suggest that dairy farmers are still unable to judge the effect on business performance in the medium to long term of the introduction of technological innovations related to animal welfare, as stated by Rutten et al. (2018) and Silvi et al. (2021).

The structural model evaluated also the relations between TPB construct and items with dairy farmers' stated behaviour. The results of this model suggest the high importance of self-awareness with respect to business investment in innovative technological instruments. In fact, investing in new technologies involves high effort by entrepreneurs in developing technical skills. As a result, a high PBC can reduce the perception of risk and encourage entrepreneurial choices toward such tools (Yang et al., 2022).

When single items variables related to farmers and firms' characteristics were included in the structural model, Operating Margins resulted as the most important variable that affect the adoption of technological tools. This result confirms what Vázquez et al., (2019) stated about agribusiness sector and it is crucial because it indicates that it is the actual availability of funds that moves dairy farmers' investments rather than intentions and SN. Moreover, also the access to the Veterinary system has significant effect on the stated behaviour. Conversely, less specialized systems such as litter and mixed systems are not related to technological innovation (Abeni et al., 2019). The access to the Veterinary system is positively related to the stated behaviour, suggesting that dairy farmers capable to use IT system to communicate with the veterinary system are more interested in animal welfare technologies contrary to other findings reporting that there is no this kind of interrelation (Kebebe et al., 2017). This variable has a twofold meaning: greater aptitude compared with IT services and greater attention to herd health aspects. The last aspect that is worthy to be considered is related to the role of entrepreneurs' characteristics.

The use of devices to improve animal welfare in agriculture, including animal husbandry, can lead to a range of benefits, including greater economic and environmental sustainability of the production process. Constant monitoring of animals can help identify health or welfare problems early, thereby reducing economic losses due to diseases or mortality. Devices that optimize feeding, waste management, and water use can contribute to reducing operating costs and minimizing the environmental impact of farming. Developing low-cost devices and accessible technological solutions for farmers is crucial to ensure that the benefits of technology are available to all, regardless of the size of the farm or available financial resources. Investing in research and development to continuously improve devices and technologies for animal welfare can lead to increasingly effective and efficient solutions, further enhancing the sustainability of the animal husbandry industry.

6. CONCLUSION

6.1. Main outcomes

The paper investigated using the extended TPB as theoretical framework and a multi variate analysis tool such as PLS-SEM dairy farmers' intention and behaviour toward the adoption of technological tools related to animal welfare. This methodological approach allowed us to meet the research questions. In particular, we found that PBC was a good predictor of intention while SN and ATT were not significant in the model. PBC and INT were used as regressors of behaviour; results indicate that a gap between behaviour and intention exists. Conversely, PBC is significant toward behaviour indicating the predominant role of self-confidence in dairy farmers' choices. TPB was integrated using dairy farmers and firms' characteristics as predictors of behaviour. Results suggest that behaviour is mainly affect by firms characteristics being age and education are not significant in the structural model. The operating margin is the driver with the highest effect in dairy farmers' behaviour indicating that the implementation of technological tools and attitudes toward innovative investments are mainly influenced by the actual availability of liquidity. Finally, also the technological specialization of the firms and IT and veterinary aspects can be important as significant predictor of behaviour.

The results of this research state the importance of developing ad hoc strategies and promoting research in

this field as crucial steps to maximizing the benefits of these technologies.

6.2. Implications

The results of this work have several implications, for academics and stakeholders in the dairy cattle sector. Considering the academic perspective, to the best of our knowledge, this is the first work using the extended TPB to describe dairy farmers' choices for technological tools related to animal welfare. Consequently, these results can provide early clues regarding this topic. In particular, the importance of TPB constructs for describing dairy farmers' intentions emerged but not as a predictor of actual behaviour. The prominent role of the operative margin was found indicating that TPB can be a good predictor for intention, but structural characteristics of firms could have an important role in describing dairy farmers' behaviour. For stakeholders, this work can help improve the characteristics of the sector. Indeed, technology investments are advisable to improve the efficiency and profitability of enterprises. Considering that the main drivers of behaviour are related to operating margin, breeding systems and the access to the IT veterinary system, policymakers could support, even though the Community Agricultural Policy, the adoption of technological tools and the acquisition of IT support for enterprise management. Such investments should be supported by appropriate training courses to improve dairy farmers' competences. Finally, since PBC is significant in the structural model, the introduction of technical training courses can also be helpful in improving the investment readiness of dairy farmers.

6.3. Limitations and future research

The main limitation of the work is the typical one for the studies involving survey area: the results are influenced by the local problems and conditions where dairy farmers conduct their activities. Consequently, the same study, if carried out in other regions, could lead to different results. However, this limitation can be mitigated by the power sampling evaluation carried out that suggested the sample size used is sufficient to make statistical inference. Another limitation of the work comes from the variables used in the model. While strengthened by such aspects the model cannot be exhaustive of behaviour, as there are multiple drivers of individuals' behaviour. In fact, only selected aspects were investigated, consequently other factors influencing dairy farmers' behaviour may play a role that was not observed in this study (i.e. entrepreneur's risk aversion, availability of funding, barriers, competition, and others). However, this limitation offers an important insight for further research. In fact, the TPB could be integrated with other constructs or single items derived from scales validated in literature or with other items that have not been considered, with the aim to increase understanding of the drivers of choice for describing behaviours. Moreover, TPB could be replaced or integrated with scales that consider other aspects such as the Norm Activation Model as the main model. Finally, the same work could be conducted in other regions and countries to assess changes in the structural model.

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From fair market value to judicial market value of real estate

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Abstract. The paper proposes a brief analysis of the main elements that, on a theoretical, normative and situational basis, affect the value of properties placed as collateral for loans, with particular reference to the value they assume in the event that they are affected by an enforced procedure instead of being subject to normal sale, in free market conditions. Starting from the classic analytical estimate of the fair market value of a real estate asset in free market conditions, the paper will define the principles the appraiser has to follow to quantify the value of the asset from which to start the judicial auction. Considering the regulatory mechanisms in place in Italy, the paper will put in evidence how a value calculated for an execution sale of a property occurring in a foreclosure process is considerably far from its fair market value and even more from its final judicial value, considered as the amount that will be recovered at the end of the sale of the property by judicial auction. For debtors and creditors, the significant differences between fair market, execution and judicial values become an increasingly topical issue in the face of the growing number of default and distress of loans.

Keywords: Auction market, Appraisal, Execution sale.
JEL codes: C13, K25.

1. INTRODUCTION

The valuation of a property intended to secure a loan poses a complex set of appraisal issues, particularly articulated due to the various interacting parties (individuals, financial institutions, policy makers) and the different purposes for which the appraisal is required: from determining the security value of assets that have been put when the property is used as a guarantee for a loan, to the value of the same assets calculated for an Execution Sale Value (ESV) placed as the starting price in a judicial expropriation sale process, or where it is necessary to predict its Judicial Market Value (JMV), where the need is, for example, to quantify the value of the portfolio of mortgage loans held by a credit institution.

The paper aims to propose a brief analysis of the main elements that, on a theoretical, normative and situational basis, affect the value of properties

Table 1. Number of mortgaged properties and related amount financed by the main type of asset (year 2021).

Categories	N. of properties	Amount financed (€ billions)
RES properties for exclusive, multiple and mixed residential use	918,302	70.23
Lands	28,865	7.13
No RES properties for mixed non-residential	23,629	10.54
Others	46,291	13.56
Total	1,017,087	101.46

Source: Agenzia delle Entrate (OMI, 2022).

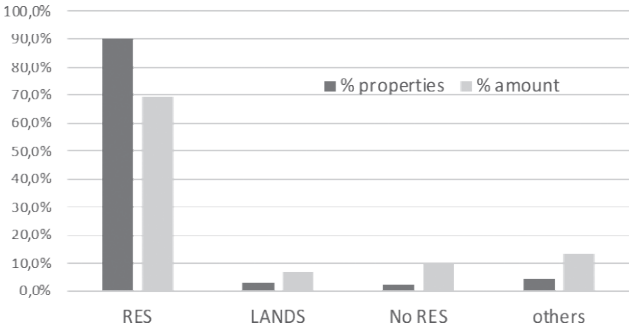

Figure 1. Percentage of mortgaged properties and percentage of the related amount financed by the main type of asset (year 2021). Source: Agenzia delle Entrate (OMI, 2022).

placed as collateral for loans, with particular reference to the value they assume in the event that they are affected by an enforced procedure instead of being subject to an ordinary sale in free market conditions.

The issue is significant considering the number of mortgaged properties in Italy. In 2021, it exceeded one million units, registering a +26% increase over the previous year: 90% of mortgages relate to properties for exclusive, multiple, and mixed residential use, 2.8% for lands and 2.3% for properties designed for mixed non-residential use. This set of properties is placed as collateral for mortgages with a financed capital exceeding 100 billion euro in 2021 (OMI, 2022).

The current economic crisis has greatly intensified cases of non-performing bank loans. It is estimated that more than one million individuals are in such conditions, for a volume of impaired loans close to 15 billion euros: 46% of these loans, amounting to 6.8 billion euros, are related to mortgages contracted for the purchase of real estate, mainly residential (Federazione Autonoma Bancari Italiani, 2023). Such a situation, given the current economic conditions, leads with increasing frequency to bank non-performing conditions and, consequently, to the initiation of legal actions to recover the remaining credit through an execution sale of the property, unless the debtor succeeds in recovering or reaches an agreement with the financial institution to proceed by recourse to a "*settlement offer*" with an "*offerta di saldo e stralcio*" (i.e. "*full and final settlement*") as indicated by the regulations in force in Italy.

The recent economic crisis, together with the pandemic period first and war conflicts later, has greatly emphasized the importance of real estate investments in the Italian economy (Locurcio et al., 2021; Morano et al., 2019). Thus, the valuation issues associated with actuation procedures broadened, especially in light of the weight that the institutional and regulatory environment has on these assets' pricing. Several scientific contributions have punctually demonstrated how regulatory provisions significantly affect the values of assets that are subject to such procedures (Pennington-Cross, 2006). Some research (Amoruso et al., 2020) goes so far as to statistically demonstrate how bureaucratic mechanisms have the upper hand, being the discount between market and execution sale value influenced to a greater extent by the duration of administrative procedures imposed by current relevant laws rather than by the physical characteristics of the assets. While in most cases the influence of institutions depresses the value of assets subject to enforcement, some studies show that in some countries auction mechanisms can even generate values that are higher than those in a fair market (Susilawati and Lin, 2006).

The findings of a series of studies comparing real estate auctions in different states have shown that institutional regulations do not always result in a depreciation of assets subject to enforcement but even in their higher valuation.

Italian laws regarding such actuation procedures have failed to substantially reduce the influence of the institutional structure, unable to curb the gap between the value that real estate properties have on the free market and when they are subject to enforcement. Even today, despite numerous adjustments, Italian regulations are extremely complex and tied to time-consuming procedures (Di Liddo et al., 2022) that make both the timing and values of capital recovery uncertain.

The regulatory changes introduced in Italy with Law 132/215 on "Urgent measures in bankruptcy, civil and civil procedural matters and the organization and functioning of the judicial administration", even if seeking to simplify and reduce the time of actuation procedures, have instead accentuated the influence of the bureaucratic process on values, resulting in a greater depreciation of properties on actuation. All this occurred in spite

of the increased transparency of the sales procedures that was achieved through the systematic use of online platforms[1] dedicated to the wider dissemination of auctions: through this system the stakeholders hoped for an increase in the number of potential buyers with which there should have been an expansion in demand and, consequently, a greater speed of adjudication with fewer discounts. However, despite these important measures, auctions are still poorly attended, as are excessive execution times and markdowns practiced. Referring to 2022, the auctions that were finalized came to an end after an average duration of more than 4.5 years, registering an average devaluation of the properties, to be intended as the difference between the initial appraisal value and the award price, equal to -29% (Reviva, 2022). Some significant studies highlight the persistent complexity of the entire judicial process and propose interesting calculation models that offer the estimator an analytical tool capable of reconciling the value of real estate determined according to the Italian appraisal doctrine with all the variables must be that belong to the particular regulatory conditions in which the auction is conducted (Tajani et al, 2021).

2. THE ESTIMATION OF A PROPERTY UNDER AN EXECUTION SALE

In setting up the valuation of a property, the appraiser must start from a careful understanding of the appraisal question, correctly interpreting the client's actual needs and considering all normative and jurisprudential indications referable to the specific case.

In the valuation of a property subject to an execution sale, Article 568 Paragraph 1 of the Italian Code of Civil Procedure (c.p.c.), according to the version revised by order of August 21st, 2015, states punctually that, for the purposes of expropriation, the value of a property must be determined in terms of its market value. In Paragraph 2 of the same article, it is also pointed out how the expert appointed by the court must carry out his assignment by indicating analytically, in addition to this value: *"… all adjustments and corrections of the estimate, including the reduction of the market value applied for the absence of the guarantee for defects of the goods sold, and specifying these adjustments separately for the costs of urban planning regularization, the state of use and maintenance, the state of possession, the constraints and legal charges that cannot be eliminated during the executive procedure, as well as for any unpaid condominium expenses".*

Interpreting the indications of art. 568 in the classic appraisal doctrinal terms, we can state that the market value indicated in the current regulatory provision is calculated considering all the advantages and disadvantages as well as the additions and deductions that concern the specific property examined, thus taking into account not only the intrinsic and extrinsic characteristics of the property in a free market scenario, but also evaluating the particular circumstances in which the sale of the property will take place, explicitly citing, among the various causes, the absence of guarantees for "hidden defects". In the case of a normal sale, these defects can be verified by the appraiser, who can thoroughly examine the property, and even if they are not detected, the law guarantees the buyer, even after the transaction for any defects that significantly reduce the usefulness and/or value of the property[2].

In determining the market value, special consideration must be given to changes that might occur in the medium to long term and are already evident at the time of appraisal. Special attention should be paid to all environmental, social and governance (ESG) risks (European Banking Authority - EBA, 2022). The European Banking Authority plays a crucial role in the European Union's banking sector, providing guidelines, standards, and recommendations to ensure financial stability and protect consumers. EBA has recently emphasised the importance of integrating ESG factors into banks' risk management processes. This includes considering environmental risks (e.g., climate change, pollution), social risks (e.g., human rights violations, labor practices), and governance risks (e.g., board structure, executive compensation) in assessing the overall risk profile of banks. As evident when considering the effects of climate change, these risks are increasingly high and heavily affect the value of real estate assets because they can both lead to lower future profitability and alter their current patrimonial value[3] (Bambagioni, 2022). These ESG risks

[1] Established and maintained by the Ministry of Justice, the Public Sales Portal (PVP) (www.pvp.giustizia.it) collects, publicizes and manages public sales that undergo through the Judicial Administration.

[2] Article 1490 of the Italian Civil Code states: "*Warranty for defects in the object sold. The seller is obliged to guarantee that the object sold is free from defects that would make it unfit for its intended use or appreciably diminish its value.*"

[3] In the real estate market, the impact of ESG is relevant considering the increasing differences in the value of properties according to their energy class, their degree of seismic safety, etc.: these aspects lead to a growing difference between new buildings and older properties. European regulations that have recently proposed mandatory measures to improve the energy class of real estate imposing upgrading expenses reduce the market value of such assets. These dynamics have major effects on the value of real estate assets placed as collateral for debt: valuing them without adequate consideration puts banks at risk of not having adequate capital in the assets placed as collateral to cover their loans.

reduce the permanence of appraisal conditions and can have a significant impact in the case of a judicial recovery transaction where, as we will see more precisely below, the conditions of uncertainty also affect the duration of the process.

The guidelines on the evaluation of properties subject to an enforcement order for the recovery of mortgages indicate market value as the economic aspect to be referred to but do not specify the procedure by which it is to be determined. In currently prevailing practice (Ministero della Giustizia, 2022), especially for the real estate market subject to judicial appraisals, market value is derived from a synthetic, multi-parameter comparative procedure, often inspired by the International Valuation Standards (IVS) as in the case of the Market Comparison Approach (MCA).

The prevalent use of this approach is consistent with the recommendations of the European Banking Authority (EBA), which urges valuations based on technical standards that, shared internationally, are suitable for increasingly globalized markets (EBA, 2020). With such approaches, an international culture of estimation finally seems to be maturing, as some scholars had hoped for many years (Forte, 1968). With particular reference to residential properties, the European Union underlines how the substantial differences in the credit policy adopted in the various Member States "*… create obstacles that restrict the level of cross-border activity on the supply and demand sides, thus reducing competition and choice in the market, raising the cost of lending for providers and even preventing them from doing business*" (Directive 2014/17 EU).

However, as some authors point out (French, 2020), each country may have different policies and different markets with varying degrees of transparency as well and, therefore, a diverse level of access to data on which to build a comparison: differences that may be such as to limit the development of a unique international valuation approach and financial policy.

3. THE FAIR MARKET VALUE AND THE FREE-MARKET CONDITIONS

Before going into the specific issues related to the valuation of a real estate subject to an enforcement order for the recovery of mortgages, it is necessary to recall the meaning to be attributed to the market value of an estate on the theoretical estimative level. The market value of an economic good expresses the amount of currency with which it will be exchanged in a market at a specific time and place. This market value will be considered as a "fair market value" if it is referred to a free (open) market. Free market conditions occur in the presence of free negotiation, with *"... all economic actors uniformly subjected to the forces acting in the market"* (Polelli, 1997). In other words, such value is obtained by matching supply and demand under conditions of free competition, with all actors operating *"...in a market governed by exclusively economic forces"* (Michieli and Michieli, 2011). These conditions should not be reduced to a perfectly competitive market: a condition that, moreover, would lead to an equivalence between the market value of the good and all the other different values (cost, subrogation, complementary and transformation) that may be associated with the same good (Medici, 1977).

These theoretical considerations regarding fair market value and free market conditions find broad confirmations with what the European Union (EU) and the Italian Banking Association (ABI) specified in this regard, with precise reference to the real estate market.

The EU, reiterating an earlier definition formulated by the International Valuation Standards Council (IVSC, 2007), considers market value as "*the estimated amount for which an asset or liability should exchange on the valuation date between a willing buyer and a willing seller in an arm's length transaction, after proper marketing and where the parties had each acted knowledgeably, prudently and without compulsion.*" (Reg. 2013/575/EU).

The reference to "*an arm's length transaction*" emphasizes that this estimated value must not be inflated or deflated by special conditions or circumstances that make trading conditions particular. In the definition, the term "*willing*" associated with the seller and the buyer is of particular importance, emphasizing that both parties must operate in the market for exclusively personal motivations without being compelled. It should also be underlined that the definition specifies how this market value should result "*after adequate marketing*", giving the owner time to bring the property to the attention of an appropriate number of potential buyers.

A similar definition of market value is formulated by the ABI in a document that, in summarizing the guidelines for the valuation of properties as collateral for credit exposures, specifies that "*Market value is a representation of the exchange value, i.e., the amount at which a property would be sold if offered for sale on the ('free') market on the valuation date under circumstances that meet defined criteria*" (ABI, 2019).

The previously formulated theoretical definition and these two operational definitions of the EU and ABI essentially express the same concepts with different words, attributing to the market value referred to the law

a meaning that generally is compatible with a "fair market value" (Fernandez, 2005). With regard to the issues under consideration, in the present work, reference will always be made to a fair market value in order to underline how the market value of a property should be associated with a market characterized by free trade conditions, in which all the actors involved in the formation of supply and demand can operate with the maximum freedom of movement and information.

4. FROM THE "FAIR MARKET VALUE" TO THE VALUE IN AN EXECUTION SALE

As pointed out in Chapter 3, the fair market value of a property must refer to a market in which the matching of supply and demand is the expression of a free choice of all interacting actors, assuming, moreover, that they operate with the time and the necessary information to be able to make informed decisions.

However, both the conditions of free choice and full awareness are lacking in the case the appraisal must evaluate a property subject to an execution sale. In fact, in such cases, almost opposite conditions are generated, with an absolute non-spontaneity of the offer and often significant information asymmetries that make the knowledge of the property incomplete and the date of the sale uncertain.

The consistency of these constraints has a very significant impact on the specific market in which a valued property is affected by an execution sale, and this is punctually quantified by the relevant differences that occur between market values and the final auction base prices at which these properties are sold.

Some statistical sources made available by private institutions operating in the field of real estate appraisals in Italy (Astasy, 2019; Immobiliare.it, 2020) have accurately quantified these differences, showing how, over time in the Italian market, the differences between auction prices and free market values have increased.

In 2007, before the financial turmoil triggered by the bankruptcy of Lehman Brothers, the auction prices were, on average, 15% lower than market values[4]. After only five years, in 2012, this deviation tripled, reaching in 2020, also due to the mechanisms introduced with the latest Italian law provisions, final auction adjudication prices of the properties even 57% lower than their market values.

As indicated earlier, Article 568 of the *Italian Code of Civil Procedure* (c.p.c.) highlights in Paragraph 1 that a property subject to an execution sale must be estimated considering its market value, and in Paragraph 2 punctually indicates the need to correct this value by considering all the "adjustments and corrections" that the conditions of expropriation impose. However, looking at the effects that Italian regulation has generated in recent years, it is evident that it does not indicate with sufficient precision the extent to which such adjustments should weight considering the particular market conditions that are generated for a property subject to an execution sale for the recovery of mortgages. The only sentence of the article that offers guidance to this effect can be identified in the following "*... reduction in market value practiced due to the absence of the warranty for defects in the property sold*" (Article 568 c.p.c.)

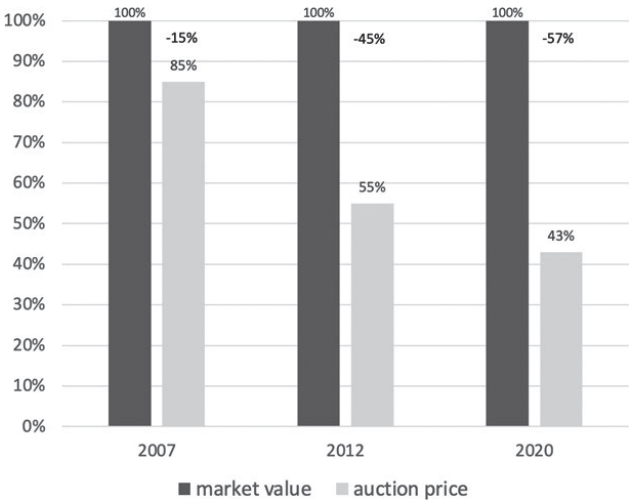

Figure 2. Consistency (%) of the base auction price compared with the free market value. Source: our elaborations on data Immobilare.it and Astasy.

This issue is specifically highlighted by ABI, which suggests that judges give appraisers a specific mandate to proceed in determining a "*market value with assumption*" (i.e. "*valore di mercato con assunzione*") (ABI, 2019). By this precise term, the Italian Association intends to emphasize the need to urge the professional to properly weigh all the conditions and truths that, surrounding the valuation under consideration, invalidate a normal market value, as already specified in EU Reg. 575/2013.

What elements should the appraiser need to consider in determining the value in an execution sale? In light of the current regulations, is it appropriate to approximate this value to the value of the mortgage portfolio held by a lending institution? We will now consider the first aspect, leaving in Chapter 5 the discussion on the second question.

[4] This deviation has long been a benchmark for appraisers when they had to quantify in their appraisals the percentage of abatement to be applied to the fair market value.

In the practice that ordinarily accompanies an execution sale, the appraiser will not be able to analytically examine all aspects that may reduce the market value of the asset. The appraiser will only be able to quantify an approximate percentage that will be used to reduce the actual market value and to determine a value for the execution sale that will be prudentially lower than the fair market value.

By examining the reports of appraisers appointed by the courts to estimate properties subject to execution sale (Ministry of Justice, Public Sales Portal 2022), it can be observed that, at the first stage, appraisers determine the properties' *Fair Market Value* (*FMV*) often adopting a Market Comparison Approach (MCA). At the second stage, to determine the *Execution Sale Value* (*ESV*), appraisers reduce the *FMV* by applying a percentage (d) that, on average, ranges from 15 to 25%:

$$ESV = FMV \cdot (1 - \delta) \quad [1]$$

Assuming that the appraiser has perfect knowledge of the property, starting from its profitability up to all the elements that will add up due to execution, it is possible to examine the procedure analytically as follows.

The first step is to determine the value of the property in a free market, adopting an Income Approach. By doing so, the *fair market value* of the property will be calculated using the following formulation:

$$FMV = \frac{I}{r'} + A - D \quad [2]$$

where:

I annual income
r' real capitalization rate[5]
A additions
D deductions

The "normal" condition is to show the property in the state of total comparability with other properties, taking into account any "Additions" (*A*) and "Deductions" (*D*) to consider the specific differences the estimated property has from all other similar assets considered for comparison. This is the value of the property sold under free market conditions.

To achieve the execution sale value (*ESV*) of the same property, the appraiser will have to consider the fair market value but correcting it considering all the particular conditions under which the sale takes place:

$$ESV = \left(\frac{I'}{r''} + A - D\right) - \sum_{p=0}^{n} \frac{(I' - I^t)_p}{(1+i)^p} - k_0 \quad [3]$$

where:

I' income of property including any permanent defects;
r'' real capitalization rate, including disadvantages due to judicial execution;
A additions; relating to normal condition of sale
D deductions, relating both to normal condition of sale and other emerging expenses due to the execution;
I^t transitional incomes due to:
– temporary defects of the estate,
– complete or partial immediate accessibility of the property;
i discount rate;
n duration of transitional income;
k_0 costs for recovery operations to remove transitory defects.

The first element that determines a difference between fair market value and the execution sale value, as moreover explicitly stated by the norm, is due to the fact that in the execution sale there are no guarantees for any "hidden defects". This problem takes on significant relevance because properties subject to execution sale cannot often be accurately examined by the appraiser, and he/she is not able to operate within the so-called "ordinary diligence". Therefore, in the case of an execution, defects represent an unknown of absolute importance that must be appropriately considered by deducting from the full market value of the property an amount that can cover the risks that in this case will be totally at the expense of the buyer of the property.

Hidden defects may be permanent and/or temporary. In the case of a permanent defect, it may result in a lower value of the property by reducing its productivity ($I' < I$) and/or generating disadvantages, reducing the desirability of the estate in the market ($r'' < r'$).

If the hidden defect turns out to be transitory, i.e., it turns out to be somewhat recoverable, it may affect the value of the appraised property:

– by reducing for a certain number of years (n) the profitability of the property ($I^t < I'$);
– by imposing costs k, related to the recovery operations that the buyer will have to undertake to remove the defects.

[5] The real capitalization rate adopted in (2) is analytically determined by first identifying a "normal" capitalization rate (r_n), deriving from the average of the capitalization rates attributable to *i-th* properties similar to the one like under estimation and for which the related annual incomes (*Ii*) and market values (MV_i) are known:

$$r_n = \frac{\sum_{i=1}^{n} I_i}{\sum_{i=1}^{n} MV_i}$$

Before being used for capitalization, the normal rate must be adjusted for the "advantages" and the "disadvantages" that the real estate possesses and that distinguish it from the other assets with which it is compared: the advantages will reduce the normal rate while, at the opposite, the disadvantages will increase it.

The lower temporary incomes indicated in Equation (3), in addition to being associated with such removable defects, may be generated by the fact that the sale resulting from the enforcement does not allow the buyer to have immediate availability of the asset in its entirety ($I_t = 0$), or only partially ($I_t > 0 < I'$).

Therefore, because of the different causes determining transitory incomes, it is important to consider how the lower profitability of the property due to hidden defects and non-immediate accessibility may also have different durations, with the former predictably being able to outlast the latter[6].

It is of utmost importance to consider that the reduction in the value of the property due to the execution sale should not be included in the other deductions that the appraiser must still take into account in an estimate of the most probable market value of the property, going from its normal value to its real value, as indicated in Equation (2). This distinction must be made by the appraiser in his report, in compliance with Paragraph 2 of Article 568 of the Italian Code of Civil Procedure, distinguishing these adjustments and corrections due to the conditions of execution sale from all other adjustments and corrections that must be considered in determining the real value of the property in a normal negotiation under free market conditions.

5. FROM THE EXECUTION SALE VALUE TO THE JUDICIAL MARKET VALUE

The execution sale value is an appropriate answer if the estimation question is dictated by the need to identify a value to be used as the auction base. But if the question is to know the judicial market value of the property at the present time, then it will be necessary to consider how the value determined for the execution sale requires further adjustment, considering the average duration of the entire process and the average number of auctions and the relative bidding rebates that will most likely be necessary for the adjudication of the property.

In accordance with some operational solutions already formulated (Moncelli, 2021), if the estimative question is to determine the judicial market value (*JMV*), such as in the case where the estimation is necessary in order to quantify the value of the property in the overall value of a mortgage loan portfolio owned by an institution, then it is necessary to reduce the execution sale value (*ESV*) in the following terms:

$$JMV = ESV \cdot (1 - \alpha) \cdot \frac{1}{(1+i)^n} \quad [4]$$

where:

α average coefficient of bidding rebates in the competent court;

$\frac{1}{(1+i)^n}$ present value factor;

i discount rate;

n average duration of auction process in the competent court.

The introduction of a present value factor into Equation (4) is necessary in order to consider that the recovery of claims may occur at a time (n) significantly distant[7] from the actuality to which the judicial value refers. The coefficient a indicates the reduction to be applied to the EVS due to the progressive auction rebates that may occur on average in the court of jurisdiction[8].

By substituting the term *ESV* in Equation (4) according to the terms expressed by Equation (3), we will achieve the following final analytical formulation of the judicial value:

$$JMV = \left[\left(\frac{I'}{r''} + A - D\right) - \sum_{p=0}^{n} \frac{(I' - I^t)_p}{(1+i)^p} - k_0\right] \cdot (1 - \alpha) \cdot \frac{1}{(1+i)^n} \quad [5]$$

Assuming that it is possible to exclude that the reiteration of auctions is to be attributed to an excessively high initial execution sale value, it is possible to say that these additional elements that further reduce the value of the property represent an aspect that is completely unrelated to any estimative logic, depending predominantly, if not exclusively, on a regulatory provision that tends to improve the efficiency of the offices (Spada, 2019) more than to ensure a fair processing of the enforcement act for the protection of all the stakeholders involved in the process.

The reduction in the value of real estate due to the reiteration of auctions must be considered when determining the value of property pledged as security for a debt. However, as proposed in this contribution, it is strongly recommended that the appraiser keep a clear demarcation between the execution sale value and the judicial market value, considering the former as the starting value to be attributed to the property to be sold

[6] While the transitory lower income attributable to the non-immediate use of the property ceases immediately upon full availability of the property, quite different may be the time required to remove the defects in the property and the related lower income attributable to it. This is also because the removal of such hidden defects can only occur naturally at the time of full availability of the property.

[7] On average, an auction in Italy takes 1,000 days.

[8] In the case of execution sale, if no suitable offers are received, the judge proceeds with a new auction (art. 532 of the c.p.c., as amended by law 132/2015). For this new auction the judge may set a new ESV, lower than the previous one, by no more than 25% (art. 591 c.p.c.).

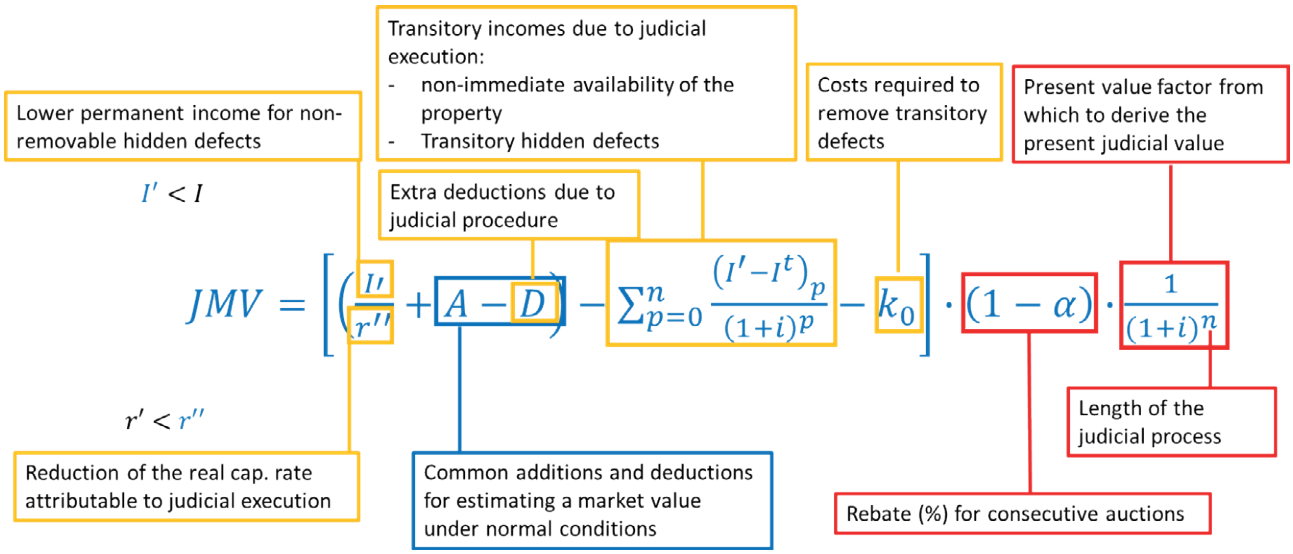

Figure 3. From the market value to the Judicial Market Value.

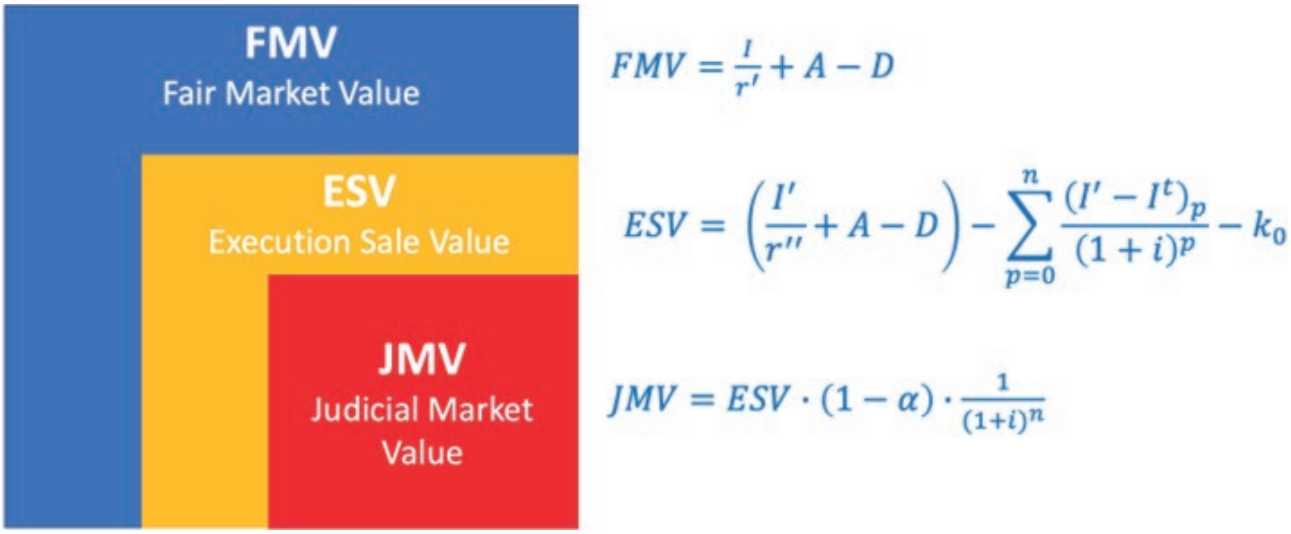

Figure 4. Comparison of the three values.

at judicial auction, while the latter will represent the most probable price that can realistically be recovered at the end of the entire procedure. The substantial difference between these two values lies in the fact that the JMV is affected by the circumstances that in the specific court may cause a different number of auctions and a different overall duration of the entire process: the punctual distinction of an ESV and a JMV allows, on the one hand, a clearer understanding of what different causes the asset gradually loses value and, on the other hand, a more realistic quantification of the amount that will be possible to recover at the end of the procedure.

We report a case study in which the above mathematical equations were implemented.

The case study refers to a residential property located in an urban area of the province of Florence. The annual income of the property, based on rent after taxes and various expenses charged to the owner, is 7,200 euros. The Fair Market Value (FMV) was calculated according to Equation (2), considering an annual real capitalization rate (r') of 2%[9] and the absence of addi-

[9] The annual capitalization rate is derived from a comparative assessment of values and rents observed for properties located in the same

tions or deductions.

The FMV resulted in 360,000 euros:

$$FMV = \frac{7{,}200\ €}{0.02} = 360{,}000 \quad [6]$$

Since it is not possible to quantify all the elements that determine the difference between the FMV and ESV, based on Mathematical equation (1), an all-inclusive percentage reduction (d) of 20%[10] is applied:

$$ESV = 360{,}000\ € \cdot (1 - 0.20) = 288{,}000\ € \quad [7]$$

This is the analytical level in which the appraiser can empirically perform his/her task because of the various constraints previously outlined in an execution sale.

However, as a purely illustrative example, to make this 20% reduction less aleatory, in accordance with Equation (3), it is possible to indicate in more detail the main elements that justify this reduction:

$$ESV = \left(\frac{7{,}200\ €}{0.0228}\right) - 7{,}200\ € \frac{1.02^2 - 1}{0.02 * 1.02^2} - 13{,}020.76\ € = \quad [8]$$

$$= 315{,}000\ € - 13{,}979.24\ € - 13{,}020.76\ € = 288{,}000$$

As conveyed in this example, the reduction in value can be analytically associated with three main aspects:

- the not-excludable presence of non-removable hidden defects;
- the non-immediate availability of the property;
- the possible presence of removable hidden defects.

The possible presence of non-removable hidden defects, an aspect that cannot be excluded because of the particular conditions due to judicial execution, is taken into account by reducing the value of the property by 10%. In the example, this reduction is totally associated with a different capitalization rate ($r''>r'$). However, this reduction could also be expressed by a lower income I ($I'<I$).

With regard to the second aspect, the non-immediate availability of the property leads to a temporary reduction in income. In this case the property is occupied and, therefore, it is conservatively assumed that the buyer will not be able to use it in any way for a period of two years: thus, in this period it is legitimate to consider the absolute absence of transitional incomes ($I^t=0$). The total amount of lost income will be given by the entire two-year discounted income (equal to a total of 13,979.24 euros).

The last aspect, related to removable hidden defects, is addressed by quantifying an amount that can cover the expenses k_0 that the new property will face to remove them (in this case 13,020.76 euros[11]).

Considering the above conditions, the ESV resulted in 288,000 euros, 20% lower than FMV.

Lastly, according to Mathematical equation (4), Judicial Market Value (JMV) was calculated, resulting in 221,453 euros, a further 20% ($\alpha=0.20$) reduction due to the general bidding discount and to the fact that the conclusion of the entire auction lasts about two years.

$$JMV = 288{,}000\ € \cdot (1 - 0.20) \cdot \frac{1}{(1 + 0.02)^2} = \quad [9]$$

$$= 230{,}400\ €\cdot 0 \cdot 9612 = 221{,}453.29\ €$$

In the case study, we obtained a JMV 38% lower than the initial FMV, in accordance with the differences in value that have been detected for many Italian courts as reported by some authors (Di Liddo et all, 2022).

6. CONCLUSION

At the estimative level, the valuation a real estate subject to an enforcement ordered for the recovery of mortgages represents a typical case in which the regulatory conditions overemphasize the difference between the price and economic value of a property (Gaca, 2018).

As illustrated in this paper, the regulatory provisions currently in force in Italy tend to heavily affect the work of the appraiser, subordinating estimative logic to legislative requirements. The recent amendments to Article 571 of the Italian Code of Civil Procedure (c.p.c.) have significantly accentuated the weight of the regulatory mechanisms on the value of property and, in particular due to the reductions in the value of property at the various auctions that may be necessary to sell a real estate, have greatly accentuated the differences between the initial fair market values (FMV), the execution sale value (ESV) and the final judicial market values (JMV). To ensure maximum transparency for all stakeholders interacting in a judicial appraisal, it is necessary that property valuations

area: on the basis of these values, the capitalization rate is derived by applying the Equation given in Note 5. In addition to being developed directly by the estimator through his or her personal knowledge of the real estate market in which he or she operates, this comparison can be obtained by consulting the national database of real estate quotations managed by the *Osservatorio delle Quotazioni Immobiliari* (OMI). In the OMI database, for each municipality and area, the unit (per square meter) values of properties and their rents are given.

[10] The % indicates an average value deduced by observing the single case study and the prevailing practice adopted by court-appointed appraisers and reported in appraisals available on the Ministry of Justice, Public Sales Portal.

[11] This sum is quantified by considering the 20% cumulative reduction adopted in mathematical equation (7) and subtracting from this value what is due to non-removable hidden defects and the loss of income generated by the non-immediate availability of the property.

are carried out with a clear distinction between these different values. The case study examined in this article is intended to offer a practical example of how to make more transparent the logic by which these different values are calculated. A further fruitful exploration would be to examine other case studies, comparing the results obtained by adopting the methodology proposed with the present paper with the ones from other approaches suggested by some previously mentioned Authors.

To achieve maximum transparency, it is advisable for the various parties involved in the valuation of a property subject to such a procedure to be immediately aware of what the most likely judicial market value of the property might be compared to its fair market value and its execution sale value. By doing so, real estate owners will have a clear indication of how much the pledged asset will be able to cover a debt, just as it will be possible to offer lenders a more realistic value of their mortgage loan portfolios and a more accurate definition of the collateral value of the asset on the basis of which to define the amount of the loan itself, adopting more analytical criteria than the prudential criteria of a percentage decrease in the short-term selling value of the property (Gallerani et al., 2011).

With respect to the above, some unanswered questions remain that might merit further estimative investigation.

In particular, more careful consideration should be given to the fact that both the execution sale value and the judicial value of a real estate are estimates that explore values referable to an unspecifiable future time, i.e. when the property may be the subject of a debt collection measure. This aspect introduces additional valuation uncertainties that will grow depending on the increasing instability of the real estate and financial markets. Therefore, to ensure that such valuations have a minimum period of validity in the long run, it is necessary, as far as possible, that they are made by reducing short-term volatility factors and temporary market trends (Ieppariello, 2015).

Finally, it would be necessary to consider how the valuation of real estate in the context of an execution sale is also often strongly linked to quite particular psychological conditioning. As pointed out at various points in the paper, it is undoubtedly true that the value reductions depend on the absence of free market conditions and the limited efficiency of the various offices. But this reduction in values is certainly also significantly affected by the discomfort that buyers and sellers face in an execution sale.

Considering the growing gap among market, execution and judicial values, it seems appropriate to consider whether recent regulatory changes, while intended to resolve some issues, have instead introduced other undesirable effects. Looking at the results to date, it seems clear that the current regulatory framework has failed to ensure greater uniformity in interpretation and disposition, nor does it appear to have been decisive in terms of speeding up procedures. It is evident how these conditions severely discourage the credit market and general socioeconomic development, going so far as to raise questions of legitimacy, particularly when the progressive decreases in judicial value, theoretically reiterated without any limit, not only lead to harming the interests of creditors, but also can result in an expropriation of property that is not respectful of the fundamental rights of each individual (Council of Europe, 1952; Spada, 2019)[12].

The regulatory mechanisms that currently govern the setting of these values in Italy increase the difficulties and uncertain conditions under which appraisers must operate. These uncertainties should not be underestimated considering the important role that property values play in a country's finances: an unchecked loss of confidence in the valuation of investment properties could, therefore, give rise to systemic risk at national level (Fernandez, 2005; Pereira Grey, 2021).

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Machine learning models in mass appraisal for property tax purposes: a systematic mapping study

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Abstract. The use of machine learning models in mass appraisal of properties for tax purposes has been extensively investigated, generating a growing volume of primary research. This study aims to provide an overview of the machine learning techniques used in this context and analyze their accuracy. We conducted a systematic mapping study to collect studies published in the last seven years that address machine learning methods in the mass appraisal of properties. The search protocols returned 332 studies, of which 22 were selected, highlighting the frequent use of Random Forest and Gradient Boosting models in the last three years. These models, especially Random Forest, have shown predictive superiority over traditional appraisal methods. The measurement of model performance varied among the studies, making it difficult to compare results. However, it was observed that the use of machine learning techniques improves accuracy in mass property appraisals. This article advances the field by summarizing the state of the art in the use of machine learning models for mass appraisal of properties for tax purposes, describing the main models applied, providing a map that classifies, compares, and evaluates the research, and suggesting a research agenda that identifies gaps and directs future studies.

Keywords: Mass appraisal, Machine learning, Property valuations, Appraisal for property tax, Systematic mapping study.
JEL codes: C53, D83, R32.

1. INTRODUCTION

Mass property appraisal has been gaining importance owing to the large share of the real estate market in economic measures, which has become one of the development indicators in several countries (Yilmazer et al., 2020).

These appraisals play a very useful role in determining the basis for calculating taxes within the jurisdiction of municipalities, e.g., Brazil's municipal property tax (IPTU). They are also widely used for calculating indemnities and implementing urban policy instruments.

According to the International Association of Assessing Officers (IAAO, 2013), mass appraisal is the process of assessing a group of properties as of a particular date using common data, standardized methods, and statistical tests.

This group of properties is, in most cases, composed of hundreds of data that need to be collected, processed, and modeled properly to reflect, with minimal error and distortion, the behavior of the real estate market in the target region. Given this large amount of data, the use of automated assessment methods is advisable.

In the literature, several primary studies have addressed the importance of using automated techniques to carry out mass appraisals for property tax, including some machine learning methods. Despite the increasing number of primary studies, none of the published systematic mapping studies has provided, to date, a comprehensive overview of the state of research in this field. A systematic mapping encompasses a broad review of primary studies in a given field, identifying what evidence is available (Kitchenham et al., 2010).

There is a need for systematic mapping studies showing which machine learning methods are used in mass appraisals for property tax purposes and how the accuracy of these methods is checked in the respective primary studies.

The present article seeks to fill this gap and provide an overview, through a systematic mapping study, of the main machine learning techniques that have been used in mass appraisals for property tax, as well as show how these techniques are measured regarding the accuracy of their results.

The main contributions of this article are:

- an overview of the state of the art on the use of machine learning models in mass appraisal for property tax purposes;
- a description of the main machine learning models that are commonly used in the field of mass appraisal for property tax purposes;
- a systematic map that classifies, compares and assesses existing research on the use of machine learning models in mass property appraisal;
- an agenda that consists in describing research gaps and suggestions for future studies with implications for practitioners and researchers; and
- an overview of core research topics and key findings on the use of machine learning models for mass property appraisal.

The remainder of this article is structured as follows: Section 2 presents background and related work; Section 3 describes the review protocol adopted to carry out this systematic mapping study; Section 4 shows the results of the present review; Section 5 discusses the main findings and research opportunities concerning the study; Section 6 describes threats to validity and, finally, Section 7 concludes this article with suggestions for future research.

2. BACKGROUND AND RELATED WORKS

This section provides background on mass property appraisal and use of machine learning models for such purpose, providing an overview of related works, including secondary studies.

2.1. Definition of mass property appraisal

Mass and individual appraisals of property differ only in scale, because they both seek to provide an accurate assessment of the value of one or more properties (McCluskey et al., 1997). According to the authors, mass appraisal arose from the need for standardized valuations when a high number of properties have to be valued.

Mass appraisals, therefore, consist in determining the values of all properties in a region or municipality, and they play an important role in property taxation. The correct estimation of values is essential to achieve equity (the same ratio for all properties between the appraisal value and the market value) and to enable fiscal justice to occur (Uberti et al., 2018).

In this way, mass property appraisal aims to systematically determine, on a large scale, the values of properties to maintain them proportional in view of their generic location and the specific characteristics of land and respective improvements, using statistical analysis or other techniques capable of accurately estimating the value of goods (Liporoni, 2014).

2.2. Machine learning models for property appraisal

In recent years, machine learning models have been used, with some degree of success, in mass appraisals for property tax. There are several machine learning models available; however, this study will only address tree-based regression models as they clearly present more accurate predictions when compared to other models (Valier et al., 2020).

Therefore, tree-based models frequently investigated in mass property appraisals will be discussed - from the simplest ones (decision trees) to their improved versions, which are popularly known as ensemble methods. The

following decision tree-based machine learning models will be addressed: Bagging (Bootstrap Aggregation), Random Forest (Breiman, 2001), AdaBoost, CatBoost, Gradient Boosting (Friedman, 2001), XGBoost and LightBoost.

There are several metrics available for evaluating the performance of machine learning models. These metrics are essential for the design, adjustment, and evaluation of models, as they seek to compare the values found for the response variable with the values predicted by the models being applied. Such comparison is performed by simplifying the results to an understandable value. The major metrics are described below:

Root-mean-square error (RMSE): Root mean square error is calculated as the square root of the mean squared differences between observed and predicted values.

Mean Square Error (MSE): Mean square error is commonly used to check the accuracy of models. Each error is squared individually, and then these squared errors are averaged.

Mean Absolute Error (MAE): The mean absolute error measures the average of the error differences between the observed and predicted values by the models without considering their direction (Islam et al., 2022).

Mean Absolute Percentage Error (MAPE): The mean absolute percentage error is the average of all percentage absolute errors, regardless of whether the error is positive or negative, providing an indication of the average size of the error, expressed as a percentage of the observed value.

Determination Coefficient (R^2): measures the goodness of fit by estimating the variation of the response variable on the basis of explanatory variables. It is a measure of the proportion of variability in one variable that is explained by the variability of the other variables.

Coefficient of Dispersion (COD): represents the average deviation, expressed as a percentage, of the assessed value of each property from the median of the assessed value divided by the observed value. Thus, the COD quantifies the extent of uniformity in appraisals by analyzing the observed variability (IAAO, 2013).

Price-Related Differential (PRD): it is an indicator that measures the degree of vertical inequality, based on systematic differences in the valuation of low and high value properties; it is suitable for large samples (IAAO, 2013).

2.3. Secondary studies on the theme

Few secondary studies have systematically analyzed the literature on specific topics regarding the use of machine learning models in mass property appraisal. Three secondary studies were identified (see Table 1): two of them are systematic reviews of the literature while one is a critical review of the literature.

These reviews addressed several topics, e.g., the use of automated methods and their results (Wang and Li, 2019), prediction accuracy using machine learning models (Valier and Micelli, 2020) and optimal models for predicting the value of properties and price indices (Ja'afar et al., 2021).

The study of Wang and Li (2019) provided a systematic review of mass appraisal models used for property tax, including works published between the years 2000 to 2018. Three main trends were identified: AI-based model, GIS-based model and mixed models, and a total of 104 articles were analyzed. Multiple linear regression models, intelligent systems, artificial neural networks, tree-based models, hierarchical modeling, cluster analysis, fuzzy set theory and reasoning-based models were reviewed. The article does not exactly focus on machine learning models for mass property appraisal, but methods are sometimes cited. One of the limitations of the study of Wang and Li is the fact that it focuses only on the Web of Science electronic database; although it reflects the trend towards this topic, such database may not contain all articles addressing mass appraisal. The article ends by citing the concept of mass appraisal 2.0, a procedure for assessing, analyzing, and testing a group of properties as of a certain date. It combines artificial

Table 1. Secondary studies on mass appraisals with machine learning models.

Year	Authors	No. of studies	Title
2019	Wang and Li	104	Mass appraisal models of real estate in the 21st century: a systematic literature review.
2020	Valier and Micelli	165	Automated models for value prediction: a critical review of the debate.
2021	Ja'afar et al.	47	Machine learning for property price prediction and price valuation: a systematic literature review

intelligence, geoinformation systems, and mixed methods for optimal modeling of spatial and non-spatial data on property.

The study of Valier and Micelli (2020) sought to identify what evidence emerges from the literature on automated assessment models. The authors critically reviewed articles that empirically investigated the effectiveness of models for property value prediction. Their review included a total of 165 studies published up to July 2019. The article advances by reviewing automated machine learning models and addresses decision trees, random forest, artificial neural networks, genetic algorithms, k-nearest neighbors and support vector machine. The results showed a certain predominance of automated machine learning models over traditional econometric models with regard to the ability to predict the market value of property. From an operational point of view, the high performance achieved in forecasting property prices makes machine learning models attractive to all traders who value, manage or trade property assets.

Finally, the study by Ja'afar et al. (2021) analyzed the use of machine learning in property appraisal to identify the best model for predicting the values of properties based on characteristics such as location, land size, number of rooms and others. For such purpose, the authors reviewed 47 studies published in the Scopus and Web of Science databases between 2009 and 2021. The authors analyzed the following models: random forest, support vector machine, gradient boosting, decision trees, principal components analysis, artificial neural networks, and k-nearest neighbors, among others. The authors reported that supervised learning is the most popular model among the reviewed articles, and random forest is the model that best predicts property value. This algorithm can easily adapt to the specificities of property data and produce accurate and effective results.

The existing secondary studies focus on analyzing machine learning models that predict the value of property, but they do not mention mass appraisal; the only study that addresses this issue does not, in reality, fully explore the use of machine learning models, nor does it focus on appraisals for property tax. Furthermore, there is a lack of systematic mapping studies that provide a comprehensive overview of the current research landscape in this field or establish a framework for the accumulated knowledge regarding mass property appraisal through machine learning models.

For the reasons mentioned above, this article aims to fill the existing gap by providing an overview of previous research on these themes, through a systematic mapping study on the use of machine learning models in mass appraisal for property tax.

3. REVIEW PROTOCOL

While a systematic review of the literature is an important means of identifying, evaluating, interpreting, and comparing all available research relative to a specific research question, a systematic mapping study focuses on existing research rather than answering a detailed research question (Budgen et al., 2008; Petersen et al., 2008). The central objective of a systematic mapping study is to identify and classify existing evidence, without necessarily synthesizing new information (Kitchenham and Brereton, 2013; Petersen et al., 2015).

Therefore, the present study was conceived as a systematic mapping study because this type of research can deal with a wide range of areas and provide systematic procedures to identify, categorize, and analyze the existing literature (Budgen et al., 2008, Kitchenham et al., 2010; Petersen et al., 2008).

3.1. Research objective and question

Peer-reviewed journal articles will be analyzed to identify the machine learning techniques that are being used for mass appraisal for property tax and to check which of these mass appraisal techniques have provided the most accurate predictions.

For the systematic mapping study, the following general research question was formulated: *What is the state of the art of the literature regarding the use of machine learning models in mass appraisal for* property *tax?*

For the sake of clarity, this research question was broken down into other specific questions, namely:

RQ-01: Which machine learning models are most frequently used in research on mass appraisal for property tax?

Today, there is still no consensus on the benefits of using machine learning techniques to perform mass appraisals for property tax, however. According to Valier and Micelli (2020), the debate around the topic confirms a greater prediction accuracy of machine learning models compared to traditional regression analysis. In this way, this research question seeks to consider all the machine learning models used in the analyzed articles and check which benchmark model is used to perform comparisons.

RQ-02: Which property typologies are most frequently addressed in studies on mass appraisal for property tax?

Mass appraisals can be applied to rural properties (Uberti et al., 2018) and urban properties, includ-

ing land, houses, apartments and business offices and stores (Velumani et al., 2022, Yilmazer and Kocaman, 2020, Fontoura et al., 2020, Zhang, 2015). In this sense, this research question intends to map the typologies frequently used in studies that involve the use of machine learning for mass property appraisal, as well as studies whose typology uses spatial components across the variables. This question also seeks to map the origin (area of study) of the data of each article.

RQ-03: How are machine learning techniques evaluated for accuracy in mass appraisal for property *tax?*

There are numerous statistical indicators capable of measuring the accuracy of a set of forecasts, and the choice of this indicator is not a marginal decision (Valier and Micelli, 2020). Therefore, this research question seeks to investigate the main performance indicators addressed in the articles. Additionally, based on the results reported in the respective studies, it intends to indicate the machine learning model that had the best performance among the calculated metrics.

RQ-04: What are the research trends and features of current studies on the application of machine learning to mass property appraisals?

A valuable tool for understanding the nature of a research area is the investigation of research trends and the systematic classification of existing studies (Petersen et al., 2008). In this sense, this research question intends to map the frequency of publications over time to identify research trends and seeks to categorize and aggregate existing studies to structure the target research area.

3.2. Execution of systematic mapping

This systematic mapping study consisted of three distinct steps: (*i*) search for articles, (*ii*) selection of articles, and (*iii*) data extraction, according to Petersen et al. (2008). These steps are described in further detail below.

3.2.1. Search for articles

To perform systematic mappings, many different electronic sources must be searched, because in general, a single data source is not expected to contain all relevant primary studies (Brereton et al., 2007). Therefore, an automated search was carried out in 4 different databases (DB) (see Table 2).

In the selection of electronic databases, the criteria encompassed: (i) the extensive research coverage across various disciplines provided by Web of Science and Scopus (Rodríguez et al., 2017), with the latter serving as a meta-library that compiles publications from numerous esteemed publishers, including Elsevier and Springer (Nakamura et al., 2022); (ii) the IEEE Xplore database, recognized as one of the foremost digital repositories in the field of computer engineering (Petersen et al., 2015), hosting a comprehensive collection of articles on machine learning; and (iii) the significance of Compendex as a vital interdisciplinary engineering database, cataloging a breadth of engineering journal titles and conference papers.

Table 2. Databases used in the present review.

Database	Search engine	Website
DB-01	Scopus	https://www-scopus.ez46.periodicos.capes.gov.br
DB-02	IEEE Xplore	http://ieeexplore-ieee-org.ez46.periodicos.capes.gov.br
DB-03	Web of Science	https://www-webofknowledge.ez46.periodicos.capes.gov.br
DB-04	Compendex	https://www-engineeringvillage-com.ez46.periodicos.capes.gov.br

In addition, the snowballing procedure was performed (Wohlin et al., 2012); the references of the five most cited selected articles were analyzed to identify relevant papers that were not returned during the automated search process.

Google Scholar was not selected as a database because the studies it returned tended to overlap with studies from the other databases included (Chen et al., 2010). However, the fact that the four chosen electronic databases index similar contents may reduce the possible threat to theoretical validity arising from failing to retrieve relevant studies.

Regarding type of document and time interval, the searches focused on peer-reviewed articles published in journals or in conference proceedings, from January 2015 to June 2022, when the present study was then developed.

Only publications written in English were selected, since it is the language mostly used in most international conferences and journals (Nakamura et al., 2022). It is also found that English is the predominant language in global communication; therefore, this systematic mapping study can be replicated by other researchers.

The search terms were defined using the five-step strategy proposed by Kitchenham et al. (2007). According to the author, one can develop the search terms by:

– Deriving key terms from the questions identifying population, intervention, and outcome;

- Identifying alternative spellings and synonyms for key search terms;
- Checking keywords in any relevant articles previously retrieved;
- Using the Boolean operator OR to incorporate alternative spellings and synonyms; and
- Using the Boolean AND operator to link key search terms.

Following this strategy, a generic search string was defined to connect key terms with Boolean operators, and several tests and refinements were carried out with it during the preliminary search. The following generic search string was used: *mass appraisal AND machine learning*.

Table 3 shows the set of search terms for the present study. As the search syntax is specific to each database, the search string was adapted to the specific syntax requirements of each of the four search engines.

The search string shown in Table 3 was tested several times with different combinations to reduce the number of articles that were not related to the research topic, thus ensuring a set of articles that were adequate to the objectives of this study. Table 4 shows the results of these searches.

To enhance the rigor of the automated search protocol, the investigation employed the snowballing method. This technique entails two complementary processes: backward snowballing, which involves tracing and analyzing the references cited in a primary article to uncover relevant studies, and forward snowballing, which consists of identifying subsequent publications that have cited the primary article. Such a strategy is instrumental in systematically broadening the scope of the research database. To mitigate any potential threats to the study's validity stemming from researcher bias, a secondary researcher independently conducted both the backward and forward snowballing operations. This approach yielded four new studies that were incorporated into the analysis database for the current mapping study.

Table 3. Overview of search terms and their synonyms.

Main Term	Search Terms
mass appraisal	("mass appraisal" **OR** "mass valuation" **OR** "mass assessment" **OR** "property appraisal" **OR** "property valuation" **OR** "real estate appraisal" **OR** "property tax" **OR** "land taxation" **OR** "taxes purposes")
	AND
machine learning	("machine learning" **OR** "data science" **OR** "data mining" **OR** "artificial intelligence" **OR** "ai" **OR** "computational intelligence" **O**R "automated valuation model" **OR** "avm")

Table 4. Search results in each of the search databases.

Scopus	IEEE Xplore	Web of Science	Compendex	Total
117	13	100	98	328

3.2.2. Selection of articles

Article selection criteria were defined to reduce the probability of bias and assess the relevance of the articles (Kitchenham and Charters, 2007). The article selection process returned a total of 328 + 4 = 332 publications. After this stage, screening was performed in two phases: (i) selection of relevant articles based on their metadata, namely title, abstract, keywords, year of publication, language of publication and publication type, and (ii) selection of relevant articles based on full text. The articles were selected by two researchers, working in a double-blind format using inclusion (IC) and exclusion (EC) criteria (see Table 5), as previously agreed between the researchers.

In this process, articles that met all the specified inclusion criteria were included and those that presented any exclusion criteria were discarded.

At first, all 330 retrieved articles were filtered using the EC-01, EC-02 and EC-03 exclusion criteria. Then, the remaining articles were uploaded to the software Rayyan (rayyan.ai) to detect duplicates by applying the EC-04 exclusion criterion. The remaining articles were then separated in the software Rayyan for an analysis of their metadata to identify the ones that were relevant for answering the research questions. During screening, the researchers read the title, abstract and keywords of the remaining articles and applied exclusion criteria EC-05, EC-06, EC-07 and EC-08. This analysis step was performed by the two researchers in a double-blind format. As selection procedures for the next step, the approach proposed by Petersen et al. (2015) was used; it is summarized in Graph 1.

To address potential disagreements, studies falling under conditions A, B, C, and D would be included in the research, while studies falling under the borderline condition E would undergo a joint analysis, and ultimately, studies under condition F would be definitively excluded. According to Petersen et al. (2015), studies categorized under condition D should be included since one of the researchers had no doubts regarding their inclusion in the systematic mapping, and therefore, they would need to be analyzed. Consequently, the studies falling under conditions A, B, C, and D were included in this system-

Table 5. Inclusion and exclusion criteria considered in the present review.

COD	Inclusion Criteria	
IC-01	Context	Articles that focused on machine learning methods and techniques for mass appraisal of urban property.
IC-02	Period	Articles published in 2015 and later.
IC-03	Location	Articles published in conference proceedings or in journals.
IC-04	Language	Articles published in English.
COD	Exclusion Criteria	
EC-01	Period	Articles published before 2015.
EC-02	Type	Items from the so-called gray literature (abstracts, books, panels, posters, editorials, short articles, reports, lectures, etc.).
EC-03	Language	Studies published in languages other than English.
EC-04	Duplicates	Articles that were duplicated, i.e., returned by more than one database.
EC-05	Reviews	Secondary studies (systematic reviews of the literature and mappings.
EC-06	Context	Articles whose abstract makes it clear that they are not related to property appraisal, even though they mentioned machine learning techniques.
EC-07	Typology	Articles whose abstract makes it clear that machine learning methods are applied for mass appraisal of rural, business or rental properties.
EC-08	Accuracy	Articles whose abstract makes it clear that they only address accurate appraisal (accurate property appraisal) and/or other studies related to appraisal engineering.
EC-09	Access:	Articles that are not available by open access, e.g., availability in the CAPES portal via the educational institution, or free availability on the Internet.
EC-10	Number of pages	Studies with five pages or less (short paper)
EC-11	Final criteria	Articles in which exclusion criteria could not be identified after reading of the title, keywords and abstract, and that were removed from the mapping after reading of the full texts, because they did not meet the inclusion criteria.

Divergence Analysis		**Reviewer X**		
		Include	Uncertain	Exclude
Reviewer Y	Include	A	B	D
	Uncertain	B	C	E
	Exclude	D	E	F

Graph 1. Analysis of divergences (adapted from Petersen et al., 2015).

atic mapping, and the studies falling under condition E underwent an assessment of uncertainties, and collectively, a decision was made regarding their definitive inclusion or exclusion from the systematic mapping.

All the articles approved in the previous stage were downloaded so that they could be read in full. They were downloaded directly from the database portals or through the CAPES/Brasil portal when they were not available by open access, and the EC-09 exclusion criterion was applied. After this step, all the downloaded articles were checked for number of pages according to the EC-10 exclusion criterion.

The articles returned in the previous step were then read in full for application of the EC-11 exclusion criterion. Full reading enabled the analysis of the articles in more detail than the previous reading of the title, abstract and keywords. The articles that did not meet the inclusion criteria were removed from this systematic mapping.

Table 6 shows the number of articles that were returned in each electronic database after applying each of the exclusion criteria shown in Table 5.

In the present review, the search string returned 328 articles (see Table 4): 117 from the Scopus meta-library, 13 from the IEEE Xplore database, 100 from the Web of Science database and 98 from the Compendex database. Figure 1 shows the number of articles that were excluded and that remained after application of each exclusion criteria (Table 5).

A total of 22 articles were selected for the data extraction stage: 18 by applying the exclusion criteria and 4 by applying the snowballing technique. Table 7 shows the selected articles and their authors.

The method of selecting articles using 2 researchers, ensures reliability in the decision to include or exclude a particular publication.

3.2.3. Data extraction

After completion of the article selection procedures, data extraction was started. The articles were categorized

Table 6. Number of articles returned after applying each exclusion criterion.

Database	EC-00	EC-01	EC-02	EC-03	EC-04	EC-05	EC-06	EC-07	EC-08	EC-09	EC-10	EC-11
DB-01	117	73	61	60	-	-	-	-	-	-	-	-
DB-02	13	8	8	8	-	-	-	-	-	-	-	-
DB-03	100	60	57	56	-	-	-	-	-	-	-	-
DB-04	98	41	36	36	-	-	-	-	-	-	-	-
Total	328	182	162	160	83	82	74	68	44	38	35	18

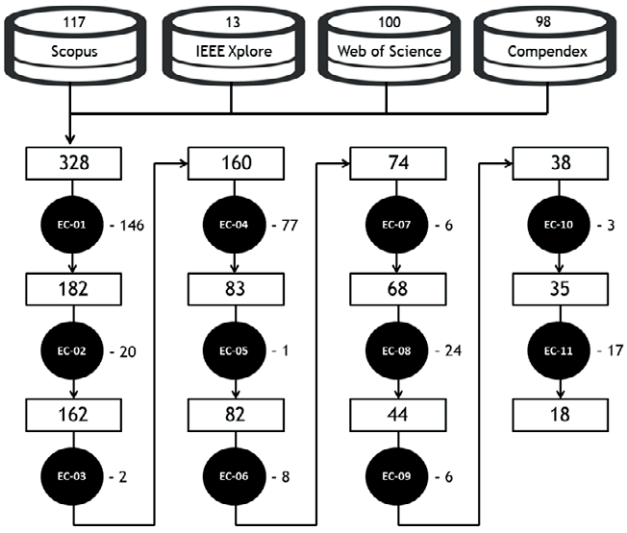

Figure 1. General structure of the answers from the data extraction form.

into different aspects (Petersen et al., 2008), since this approach is considered as a structured way to perform such a task. Therefore, the data extraction form brought together four different aspects, all related to the research questions listed in this review.

To reduce bias in the data extraction results, two researchers, based on a common understanding, performed the data extraction independently and, after the extraction process was completed, they discussed the results together and resolved conflicts to reach a consensus. Figure 2 shows the general structure of the DEF form (Data Extraction Form), which consists of four main research questions and four secondary research questions.

– **Models most frequently used in the selected articles (RQ-01)**

This research question was broken down into a major question *RQ-01: Which machine learning models were used in the study?*, whose answers could be *(a) decision trees; (b) bagging, (c) random forest; (d) adaboost; (e) gradient boosting; (f) XGBoost, (g) LightGBM* and *(h) other* and a secondary question *RQ-1.1: which benchmark model was used in the study?*, whose answers could be *(a) multiple linear regression; (b) spatial regression* and *(c) other.* When an analyzed article reported the use of more than one machine learning model (RQ-01 or RQ-1.1), a new row was added to the spreadsheet for each new model reported.

– **Most common typologies in the selected articles (RQ-02)**

This research question was also subdivided into a main question *RQ-02: What type of* property *was modeled in each study?*, whose answers could be *(a) urban land; (b) urban houses* and *(c) apartments*; and two secondary questions *RQ-2.1: What is the origin of the data set used in the study?,* whose answer would be the country of location of the data used in the study and *RQ-2.2: Did the study consider the spatial dimension when performing data modeling?,* whose answers could be *(a) did not consider it, (b) considered it as a predictor variable* and *(c) performed spatial modeling.*

– **Assessment of accuracy among selected articles (RQ-03)**

This research question was also broken down into a main question *RQ-03: Which indicator was used to evaluate the performance of the models?*, whose answers could be (a) RMSE; (b) COD; (c) PRD; (d) MSE; (e) MAE; (f) MAPE; (g) R^2 *or (h) other;* and a secondary question *RQ-3.1: Which model had the best performance in the analyzed study?*, whose answers could be *(a) decision trees; (b) bagging, (c) random forest; (d) adaboost; (e) gradient boosting; (f) XGBoost, (g) LightGBM* and *(h) other.* When the analyzed document reported more than one metric in RQ-03 or in RQ-3.1, a new row was added to the spreadsheet for each new information reported in the study.

– **Research trends and study characteristics (RQ-04)**

To assess research trends and study characteristics, data were collected regarding: *title, authors, source*

Table 7. Articles selected for the data extraction phase.

ID	Title	Authors	Year
S-01	The effect of google drive distance and duration in residential property in Sydney, Australia	Nejad, Mehrdad Ziaee; Lu, Jie; Asgari, Pooyan; Behbood, Vahid	2016
S-02	Applying dynamic Bayesian tree in property sales price estimation	Nejad, Mehrdad Ziaee; Lu, Jie; Behbood, Vahid	2017
S-03	Estimation and updating methods for hedonic valuation	Mayer, Michael; Bourassa, Steven; Hoesli, Martin; Scognamiglio, Donato	2018
S-04	An intelligent automatic valuation system for real estate based on machine learning	Niu, Jiafei; Niu, Peiqing	2019
S-05	Deep learning with XGBoost for real estate appraisal	Zhao, Yun; Chetty, Girija; Tran, Dat	2019
S-06	Sensitivity analysis of machine learning models for the mass appraisal of real estate: case study of residential units in Nicosia, Cyprus	Dimopoulos, Thomas; Bakas, Nikolaos	2019
S-07	A house price valuation based on the random forest approach: the mass appraisal of residential property in South Korea	Hong, Jengei; Choi, Heeyoul; Kim, Woo-Sung	2020
S-08	A mass appraisal assessment study using machine learning based on multiple regression and random forest	Yilmazer, Seckin; Kocaman; Sultan Kocaman	2020
S-09	Implementing a mass valuation application on interoperable land valuation data model designed as an extension of the national GDI	Aydinoglu, Arif Cagdas; Bovkir, Rabia; Colkesen, Ismail	2020
S-10	Using machine learning models and actual transaction data for predicting real estate prices	Pai, Ping-Feng; Wang, Wen-Chang	2020
S-11	Mass appraisal with a machine learning algorithm: random forest regression	Sevgen, Sibel Canaz; Aliefendioglu, Yesim	2020
S-12	Spatial prediction of housing prices in Beijing using machine learning algorithms	Yan, Ziyue; Zong, Lu	2020
S-13	A gradient boosting method for effective prediction of housing prices in complex real estate systems	Almaslukh, Bandar	2021
S-14	Developing automated valuation models for estimating property values: a comparison of global and locally weighted approaches	Doumpos, Michalis; Papastamos, Dimitrios; Andritsos, Dimitrios; Zopounidis, Constantin	2021
S-15	Predicting property prices with machine learning algorithms	Ho, Winky K.O.; Tang, Bo-Sin; Wong, Siu Wai	2021
S-16	Property mass valuation on small markets	Gnat, Sebastian	2021
S-17	A new appraisal model of second-hand housing prices in China's first-tier cities based on machine learning algorithm	Xu, Lulin; Li, Zhongwu	2021
S-18	Using machine learning to forecast residential property prices in overcoming the property overhang issue	Yee, Lim Wan; Bakar, Nur Azaliah Abu; Hassan, Noor Hafizah; Zainuddin, Norziha Megat Mohd; Yusoff, Rasimah Che Mohd; Rahim, Nor Zairah Ab	2021
S-19	Machine learning based predicting house prices using regression techniques	Manasa, J.; Gupta, Radha; Narahari, N.S.	2021
S-20	GIS & machine learning based mass appraisal of residential properties in England & Wales	Mete, Muhammed Oguzhan; Yomralioglu, Tahsin	2022
S-21	Mass appraisal as affordable public policy: open data and machine learning for mapping urban land values	Carranza, Juan Pablo; Piumetto, Mario Andres; Lucca, Carlos Maria; Silva, Everton da	2022
S-22	A comparative study of machine learning and spatial interpolation methods for predicting house prices	Kim, Jeonghyeon; Lee, Youngho; Lee, Myeong-Hun; Hong, Seong-Yun Hong	2022

(conference or journal), year of publication, author affiliation, authors' country of origin, number of study citations, abstract, keywords, name of conference or journal, place of conference, DOI code. Part of this information is extracted directly from the metadata of each article or directly from the publication's website. The number of citations for each article, up to June 2022, was collected directly on the platform semanticscholar.org.

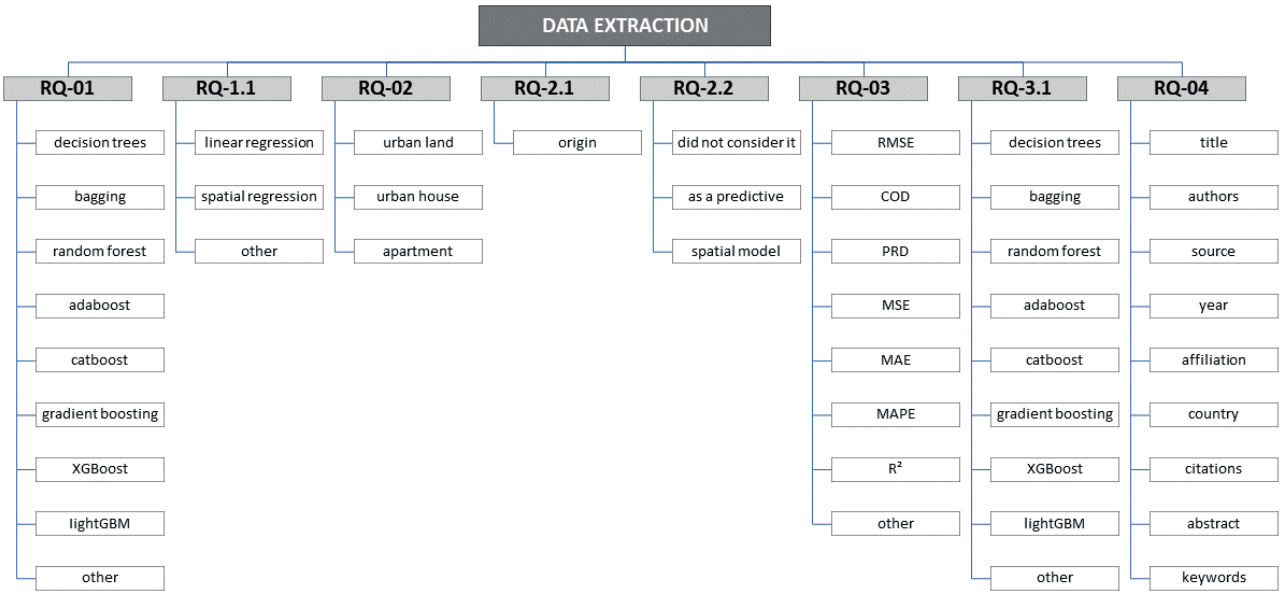

Figure 2. General structure of data extraction form (DEF) responses.

4. RESULTS

This section presents the answers to the formulated research questions (see Section 3.1). This section is organized according to the research questions.

4.1. Research Question 01 (RQ-01)

The first research question sought to identify which machine learning models, among those listed in the question itself (tree-based models), have been used in research that relates machine learning and mass property appraisal. The tree map (Figure 3) shows the absolute predominance of articles that tested the Random Forest model. There are exactly twice as many studies using this model when compared to the Gradient Boosting and XGBoost models. Among the machine learning models evaluated, AdaBoost was the least used among the analyzed studies.

The Random Forest modeI was used in 82% of the 22 selected studies; 41% performed analyses with the XGBost and Gradient Boosting methods; 18% tested the Decision Trees model; 14 % analyzed the LightGBM and Bagging models; 9% tested the AdaBoost algorithm, and only 5% of the studies tested the CatBoost algorithm.

As a sub-issue of research question 1, the benchmark model adopted by the studies was mapped to compare the results with those found by the machine learning models. Traditionally, multiple linear regression, in which the value of property is assumed to be dependent on the available characteristics, is used as a benchmark

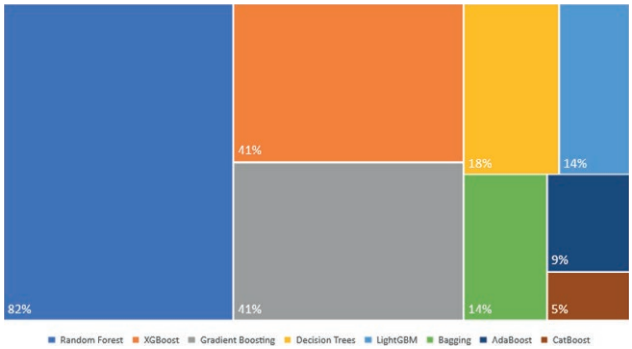

Figure 3. Tree with the machine learning models analyzed in the studies.

in property valuation (Steurer et al., 2021). The graph in Figure 4 shows these results. Most studies used multiple linear regression as a reference model. Among the 22 studies analyzed, 59% used multiple linear regression, 5% used spatial regression, and 36% used some other method of comparison to check the performance of machine learning-based models.

4.2. Research Question 02 (RQ-02)

This research question sought to map the typology of the properties modeled in each of the selected studies. Most studies used apartments for typology modeling. Among the selected studies, 59% used data on apartments; 32% on houses and 9% on urban land.

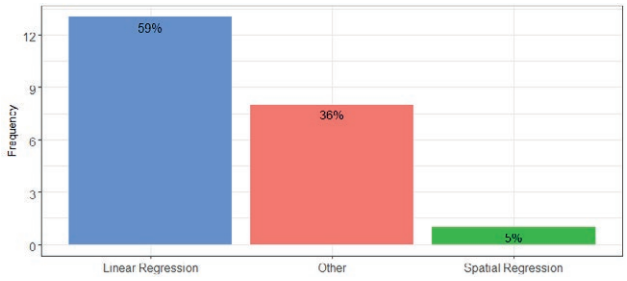

Figure 4. Model used as the main benchmark in the selected studies.

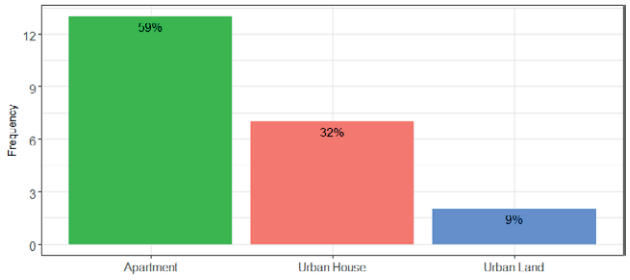

Figure 5. Typology of properties analyzed in the studies.

A research sub-issue sought to identify how the spatial dimension was explored in the studies, as shown in Figure 6. It was found that more than half of the studies used the spatial dimension only as a predictor variable. In total, 55% of the studies collected the UTM coordinates of the properties in the sample and used this information as two more predictor variables in the total set of variables. Importantly, among these 12 studies, Carranza et al. (2022) additionally calculated the Moran Global Index to verify the spatial autocorrelation of the data. It was also found that 40% of the studies disregarded the spatial dimension, i.e., they did not refer to these variables in the modeling process. Finally, 5% of the studies considered the spatial dimension by performing spatial regression. This finding about the spatiality of the data opens the possibility of carrying out research in which the spatial dimension is considered in spatial models of machine learning.

Finally, the graph in Figure 7 addresses the sub-issue aiming to identify the geographical location of the real estate data used in each analyzed study. It is observed that, in the majority of studies, the real estate data used originate from the researchers' affiliated country. However, there are exceptions, such as in the case of Carranza et al.'s study (2022), in which researchers affiliated with the University of Córdoba, Argentina, used real estate data from Fortaleza, Brazil. Additionally, another

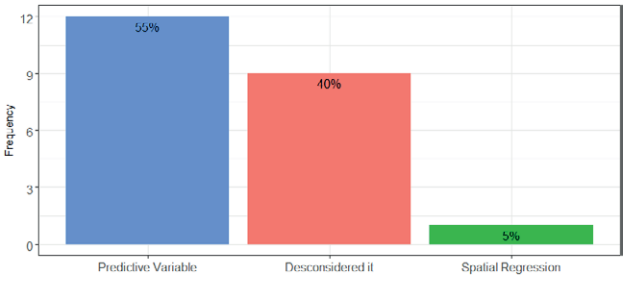

Figure 6. How the spatial dimension was considered in the studies.

interesting case was identified in which real estate data from the United Kingdom were explored by researchers affiliated with Istanbul Technical University, Turkey, as per Mete and Yomralioglu (2022).

Table 8 shows that three studies were conducted in Australia, China and Turkey, respectively. Taiwan and South Korea were the study area of two studies, each. Finally, there are several other countries that were data sources only once, e.g., Greece, Cyprus, India, Poland, Malaysia or Hong Kong. This finding indicates that there is room for researchers to investigate the behavior of machine learning models for mass property appraisal in other regions that are still little explored, or make use of new models in regions previously investigated to compare the results of both studies.

4.3. Research Question 03 (RQ-03)

This research question seeks to identify the indicators used in the studies to check the performance of the models. It was found that 82% of the studies calculated RMSE, i.e., it was the metric most often used by researchers when they wished to check the quality of machine learning models while carrying out mass property appraisals. The MAE and MAPE indicators were each calculated for 50% of the selected studies. The MSE indicator was adopted in only 10% of cases.

It should be noted that metrics such as the coefficient of dispersion (COD) and the price related differential (PRD), strongly recommended in mass appraisals for property tax by the IAAO (2013), were calculated in only 23% and 14% of the studies, respectively. Figure 8 shows the results of this analysis.

Indicators such as COD and PRD are calculated by comparing the values predicted by the models with the values found in the market, and checking if the dispersion between these values falls within the limits established by the aforementioned standard. COD is a measure of horizontal dispersion that provides information on the standardized evaluation of the set of properties

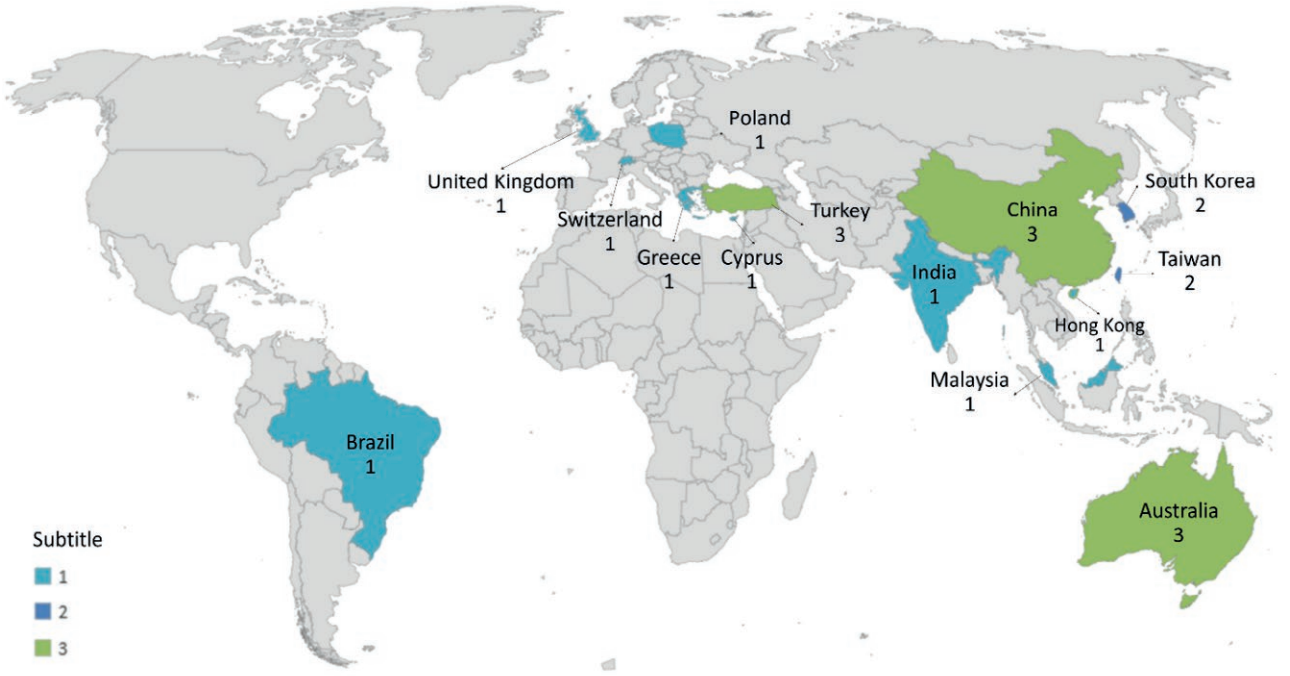

Figure 7. Number of studies and source of data in use.

Table 8. Number of studies whose data source is the country informed.

Country	Number of Studies	Country	Number of Studies
Hong Kong	1	Greece	1
Poland	1	Switzerland	1
Cyprus	1	Taiwan	2
United Kingdom	1	South Korea	2
Brazil	1	Turkey	3
Malaysia	1	China	3
India	1	Australia	3

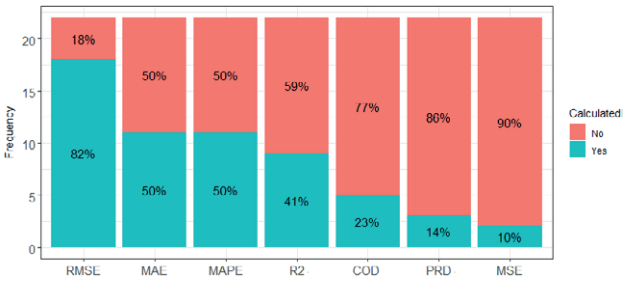

Figure 8. Performance metrics calculated in the selected articles.

while PRD is a measure to detect systematic differences in the appraisal of high- and low-value properties; it checks whether an appraisal is regressive or progressive (IAAO, 2013). These metrics are important indicators of possible inequity in the property taxation process.

A sub-issue of this research question sought to map which machine learning model had the best global performance in predicting property values. In each analyzed study, the model described by the authors was considered as the one that had the best performance or, in the absence of this information, the one that presented the best results for the set of adopted metrics.

The graph in Figure 9 shows that the Random Forest model was the one that presented the best performance in most of the selected studies. Exactly 50% of the studies reported that Random Forest is the best machine learning model for mass property appraisals. The XGBoost and Gradient Boosting models appear with the same number of citations: each was reported as the best performing model in 23% of the studies. Finally, only 4% of studies reported another machine learning model as having best performance.

To complement this research sub-issue and elucidate some important points, the graph in Figure 10 shows, among the 22 selected studies, the machine learning models checked in each selected study. The model marked with a green circle is the one that was consid-

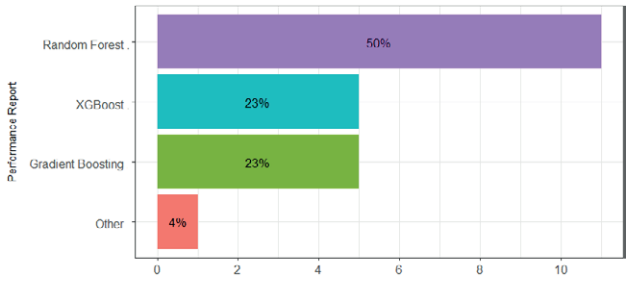

Figure 9. Models with the best performance in each analyzed study.

ered, in the respective study, as having the best global performance among all the analyzed models.

Among the 18 studies that included the Random Forest model in the analysis, this model had the best performance in 61% of them. Studies S-05, S-10, S-16 and S-19 did not test the Random Forest model in their analyses.

Another relevant aspect is that in studies S-05, S-16 and S-19, only two machine learning models were tested: XGBoost and another that is not part of the scope of models analyzed in this systematic mapping. In all these three studies, the XGBoost model showed the best performance.

Finally, it should be noted that the Gradient Boosting model performed better in most cases in which it was applied. The model appeared in 9 studies and performed better in mass property appraisals of 5 studies, which accounts for 55% of the total number of studies that used it.

4.4. Research Question 04 (RQ-04)

In order to map research trends and characteristics, an analysis was made of the set of variables found in each of the 22 selected articles. The main facts extracted from this analysis are detailed below.

4.4.1. Evolution of studies over time

The graph in Figure 11 shows that the number of published studies involving the use of machine learning models for mass property appraisal has been growing since the publication (2016) of the first study retrieved. The regression line, adjusted to the data, shows a growing trend in the studies, i.e., there is an increasing interest of the research community in this topic. Importantly, this systematic mapping considered data collected up to June, 2022, which explains the small number of studies for the trend of publications for the respective year.

Except for 2015, at least one study was published every year within the observation range. It is found that, from 2019 onwards, research on this topic began to grow at a faster rate - a fact observable through the slope of the regression line when considering the data as of the respective date.

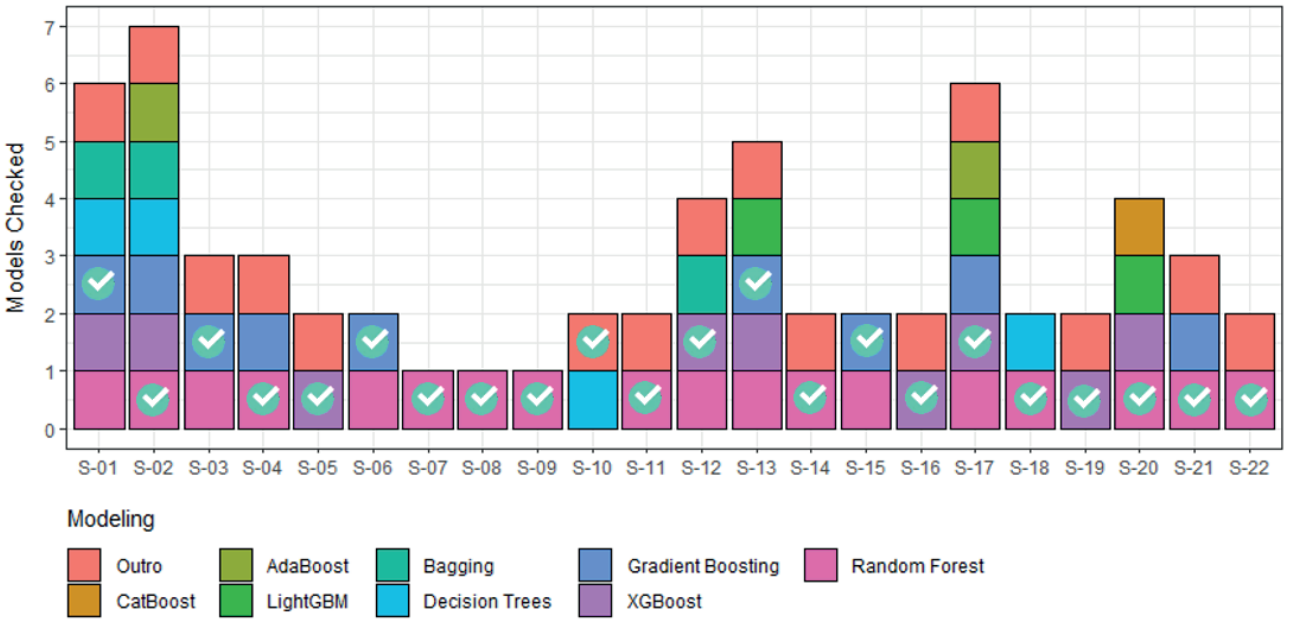

Figure 10. Models analyzed in each study and their best performance.

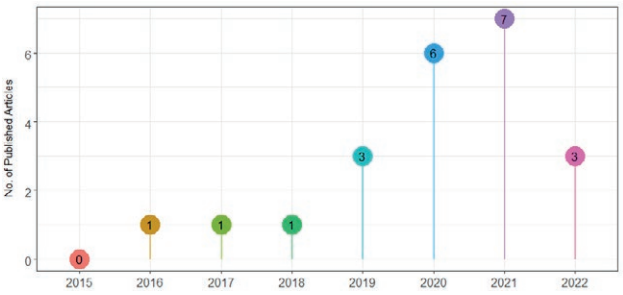

Figure 11. Evolution in the number of publications over the years.

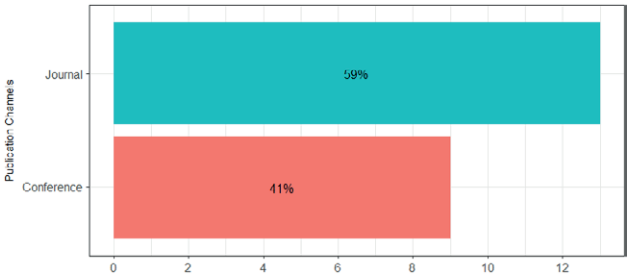

Figure 12. Number of studies by publication channel.

Figure 13. Evolution of studies by publication channel over time.

4.4.2. Main channels of publication of studies

The graph in Figure 12 shows that most studies were published in scientific journals. Among the 22 selected studies, 59% were published in some scientific journal and 41% in conference proceedings.

A greater number of articles published in journals may indicate that the topic is becoming a more mature area of research (Uludag et al., 2022), although it is relatively recent. In general, researchers prefer to publish their articles in journals because this type of publication brings more scientific benefits.

The evolution of studies by publication channel, as seen in Figure 13, indicates a growing trend in the past four years for publications in both conference proceedings and journals. However, it is noted that in each of the last three years, the number of publications in scientific journals exceeded the number of publications in conference proceedings. This observation reaffirms, once again, that the use of machine learning in property appraisal has become a more mature field of research, with the publication of more robust and comprehensive studies in recent years.

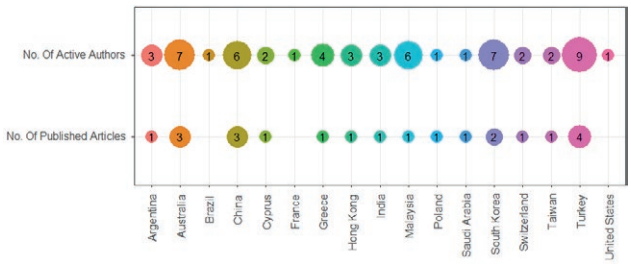

Figure 14. Countries with the most publications and active authors.

4.4.3. Most active countries in the field of studies

The graph in Figure 14 shows the most active countries in research relating machine learning and mass property appraisal. There was a total of 17 countries with active researchers, and Turkey stood out for having with the highest number of publications. It had 18.2% publications about this topic, within the analyzed time interval, and these publications were produced by 9 researchers. The analysis of the graph shows that the most active countries in publications in this area of research are Australia, China and Turkey, and the countries that concentrate the largest number of researchers are Australia, China, Malaysia, South Korea and Turkey. In Brazil, France and the United States, there are also active researchers.

This finding demonstrates that these scholars participate in international research networks, thus collaborating with the advancement of scientific research on the theme of this review. It also shows that the use of machine learning in the process of mass property appraisal is a globally relevant research topic.

4.4.4. Affiliation of researchers active in the field

Among the active authors in research related to the use of machine learning in mass property appraisal, Mehrdad Nejad, Jie Lu, and Vahid Behbood (University of Technology Sydney) stand out, each with two published works. As depicted in Figure 15, the institutions with the highest number of active researchers in this systematic mapping are observed.

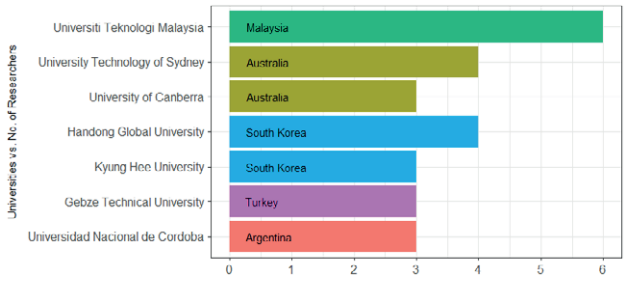

Figure 15. Universities with the highest number of active researchers.

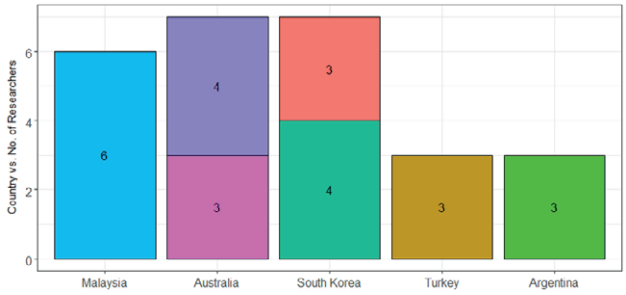

Figure 16. Countries of universities with the highest number of active researchers.

Regarding the affiliation of active researchers, it is noted that, among the 22 selected studies, all researchers are affiliated with a university. Universiti Teknologi Malaysia, University of Technology Sydney, and Handong Global University stand out as the top three institutions with the highest number of active researchers in studies related to the use of machine learning in mass property appraisal. These three universities respectively have six, four, and four researchers.

Figure 16 shows that, among the universities with the highest number of active researchers, one is located in Malaysia (six researchers), two in Australia (seven researchers), two in South Korea (seven researchers), one in Turkey (three researchers) and one in Argentina (three researchers). It should also be noted that the seven universities with the highest number of active researchers were located across virtually all continents: the Americas (Argentina), Asia (North Korea and Malaysia), Eurasia (Turkey) and Oceania (Australia). This reinforces the idea that the topic addressed in this systematic mapping is a globally relevant research topic.

4.4.5. Number of citations of selected articles

The number of citations of the studies selected for this systematic mapping, as shown in Figure 17, shows

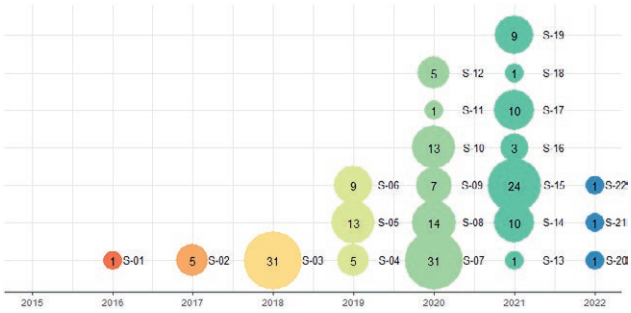

Figure 17. Number of citations of the studies considered in this review.

an increasingly relevant impact on the scientific community.

Publications S-03 by Michael Mayer et al. and S-07 by Jengei Hong et al., present the greatest number of citations according to the Semantic Scholar: 31 citations for each article, on the date this information was collected. The studies S-15 by Winky K.O. Ho et al. and S-08 by Seckin Yilmazer et al., had 24 and 14 citations each, respectively.

All four studies with the highest number of citations were published in scientific journals: S-03 in the Journal of European Real Estate Research, S-07 in the International Journal of Strategic Property Management, S-15 in the Journal of Property Research and S-08 in Land Use Policy. This reinforces the evidence that publications in scientific journals enjoy greater prestige in the research community. This finding is even more relevant when considering that in 2020 and 2021, a period in which publications in scientific journals increased, the number of citations of the studies present in this systematic mapping also increased, in comparison to conference proceedings. The scientific journal Land Use Policy received the highest number of publications among the analyzed studies: S-08 by Seckin Yilmazer et al. and S-21 by Juan P. Carranza et al.

4.4.6. Cloud of keywords cited in the studies

In scientific studies, the selection of keywords aims to facilitate the efficient retrieval of the content of a text for readers (Garcia et al., 2019). In this sense, the set of keywords of a scientific study allows other researchers to find it when they are carrying out research on that topic.

All keywords of the studies of this systematic mapping were searched, and Figure 18 and Table 9 were designed with the word cloud to show the absolute frequency of the 10 most cited keywords in the respective articles.

Figure 18. Keyword cloud of the studies considered in this review.

Table 9. Frequency of the 10 keywords most cited in the articles.

Word	Frequency
machine learning	12
mass appraisal	6
random forest	5
property valuation	4
real estate valuation	3
real estate	3
automated valuation models	3
house prices	2
gradient boosting	2
regression	2

These keywords show the strong relationship between 'machine learning' and 'mass appraisal'. These were the two most cited keywords; 'machine learning' was cited twice as many times when compared to 'mass appraisal', which was the second most cited keyword. These two keywords are closely related to the theme of this systematic mapping: machine learning models for mass property appraisal.

Other words also featured prominently in the keyword cloud, e.g., the machine learning algorithms 'random forest' and 'gradient boosting', as well as words related to the real estate market, such as 'property valuation' and 'real estate'. This keyword cloud presents evidence of the strong relationship between the topic addressed in this systematic mapping and the articles selected for this analysis.

5. DISCUSSION

This section shows the analysis of the results of this systematic mapping study. It also highlights issues that need to be further explored and makes some suggestions for future research.

5.1. Analysis of results

Considering the set of 332 works returned in the initial searches, including those of the snowballing process, this systematic mapping study was carried out with a final selection containing 22 studies, which sought to answer the central question of this review: *What is the state of the art of the literature regarding the use of machine learning models for mass property appraisal?* The small number of selected studies may be explained by the fact that research is still incipient regarding the use of machine learning algorithms based on regression trees for property appraisal; in addition, the focus was on studies that directly associated the use of machine learning with mass property appraisals. However, despite the small number of publications, there are gaps that can pave the way for new research opportunities and challenges that can serve as a basis for future researchers to explore the theme of the present mapping study.

It was found that *the most frequently used machine learning models in research on mass property appraisal* (**RQ-01**) are Random Forest, Gradient Boosting and XGBoost, Decision Trees, LightGBM, Bagging, Ada-

Boost and CatBoost. However, the use of the Random Forest model is predominant (S-01, S-02, S-03, S-04, S-06, S-07, S-08, S-09, S-11, S12, S-13, S-14, S-15, S-17, S18, S-20, S-21 and S-22) in research on the use of machine learning for mass property appraisals. The results of these machine learning models are, in most cases, compared with the results achieved by the multiple linear regression model (S-01, S-03, S-04, S-06, S-07, S-08 , S-12, S-14, S-16, S-17, S-18, S-19, S-21), which is often used by engineers and researchers when carrying out mass appraisals for property tax. Importantly, there was only one study (S-22) that compared the results of the machine learning models with those found by the ordinary kriging model.

The property typologies most frequently addressed in studies on mass property appraisal (**RQ-02**) are urban land (S-16 and S-21), urban houses (S-02, S-03, S-04, S-05, S-13, S-19 and S-20) and apartments (S- 01, S-06, S-07, S-08, S-09, S-10, S-11, S-12, S-14, S-15, S-17, S-18 and S-22). However, only one of these studies (S-17) considered the spatial dimension of the data, represented by spatial regression. Among these studies, 12 chose to use the UTM location coordinates of the properties as a predictor variable while another 9 studies did not use the spatial dimension in their analyses. Previous studies used data from different sources; three studies used data from properties located in Turkey (S-08, S-09 and S-11); three studies, from properties in China (S-04, S -12 and S-17), and three other studies, from properties located in Australia (S-01, S-02 and S-05). There are also data from properties located in countries such as Greece, North Korea, Switzerland, Brazil, and India.

It was found that *machine learning techniques are assessed, with respect to the accuracy of machine learning modeling (***RQ-03**) by several indicators. The most frequent in the studies selected in this systematic mapping were RMSE, COD, PRD, MSE, MAE, MAPE and R^2. Among these indicators, both RMSE and MAE are the most regularly used in model assessment studies; however, it cannot be argued that RMSE outperforms MAE, or vice versa; instead, a combination of metrics, including, but certainly not limited to, RMSEs and MAEs, is often required to assess model performance (Chai and Draxler, 2014). According to Bicak (2021), RMSE and MAE have informative value; therefore, it is advisable to use both. The RMSE indicator, calculated by using the square root of the mean squared differences between the observed and predicted values, is the one that appears in the vast majority of studies (S-01, S-02, S-03, S-04, S-06, S-08, S-09, S-11, S-12, S-13, S-15, S-16, S-17, S-18, S-19, S-20, S- 21 and S-22), whereas the MAE indicator, which measures the average of the error differences between the observed and predicted values by the models without considering their direction (Islam et al., 2022), was calculated by a smaller number of studies (S-02, S-03, S-05, S-06, S-09, S-10, S-12, S-13, S-18, S-20 and S-22). Indicators such as COD (S-06, S-07, S-08, S-09 and S-21) and PRD (S-08, S-09 and S-21), strongly indicated for analyzing the quality of mass assessments (IAAO, 2013), were calculated by few studies. It was also found that among the machine learning models used for mass property appraisal in the 22 analyzed studies, the Gradient Boosting model was cited as the one that presented the best global accuracy in 5 studies (S-01, S -03, S-06, S-13 and S-15); the XGBoost model was cited in another 5 studies (S-05, S-12, S-16, S-17 and S-19) and, finally, the Random Forest model was cited in 11 studies (S-02, S-04, S-07, S-08, S-09, S-11, S-14, S-18, S-20, S-21 and S-22).

5.1. Suggestions for further research

Based on the contributions of this systematic mapping study, the following suggestions for future research can be made:

(i) Conducting research that makes combined use of machine learning models and geostatistics: No studies were found that combined geostatistics with machine learning for mass property appraisals. There are studies combining these two techniques in other areas; for example, Su et al. (2020) examined the combination of these techniques to estimate biomass in Chinese forests; however, in the area of mass appraisals, there are no studies to date.

(ii) Exploring feature engineering for selection of relevant variables and comparison with traditional modeling: among the studies analyzed, some used feature importance for modeling purposes. However, there were no studies that demonstrate the gain in accuracy when comparing the results of modeling with and without the application of feature importance.

(iii) Developing a method of mass property appraisal using spatial random forest regression: the analyzed studies demonstrated the use of the spatial dimension in the form of inclusion of a new predictor variable; however, no studies were found that actually performed the spatial random forest regression process (Benito, 2021). This study demonstrated that the random forest model shows good predictive performance even when using many covariates with nonlinear relationships, while the spatial regression model shows good predictive performance when using many records that are spatially autocorrelated. Thus, the application of the spatial random forest

regression model can be an interesting strategy to explore.

(iv) **Checking the accuracy of machine learning models for property appraisals in other regions:** among the analyzed studies, few of them have explored the use of machine learning techniques in urban land (S-16 and S-21), and few countries have explored these techniques in mass appraisals. In Brazil, for example, there is only one study that used machine learning models for mass appraisal of urban land in the city of Aracajú. Studies with data on land from other Brazilian municipalities or even new typologies, such as houses and apartments, are an alternative for comparing the effectiveness of machine learning models in mass appraisals for property tax.

6. THREATS TO VALIDITY

This systematic mapping study was conducted following a rigorous methodology, with special attention to the selection and analysis of published studies. Although this methodology is widely employed by various authors, it does have some limitations. The results observed in this research may be affected by threats to validity, despite attempts to mitigate them throughout the stages of this systematic study. For example:

(i) **Article selection bias:** to minimize this threat, both the protocol and the execution process were reviewed by experienced researchers. To further mitigate the article selection bias, a set of criteria was created, as presented in Section 3.2.2; it sought to ensure that the most relevant publications were found by search engines. For this process, the most important terms related to the use of machine learning in mass property appraisals were selected, and a generic search string was designed. The focus was on studies published in conference proceedings or in scientific journals. The objective was, therefore, to determine the state of the art of high-quality, peer-reviewed scientific articles that followed strict publication guidelines.

(ii) **Incomplete searches:** owing to the exclusion criteria adopted, this systematic mapping study may not have reached exactly all the studies on the topic, which may affect the completeness of the present study. For example, by creating an exclusion criterion that eliminates all studies that were not in English, relevant research studies published in different languages, such as Portuguese, were ignored. To mitigate this risk, studies were carried out in electronic databases commonly used in the engineering area and which contain a large number of indexed journals and conference proceedings.

(iii) **Data extraction bias:** the accuracy of the results of a systematic mapping study can be strongly affected by researcher bias in data extraction. To mitigate the impact of potential researcher bias on data extraction, two researchers specified a list of items to be extracted and reached a consensus on the understanding of each of these specified items. The set of primary studies selected in this systematic mapping was then distributed to the two researchers and they both carried out, independently, the extraction of data from all studies. Discrepancies arising from the data extraction process were resolved together, through a consensus meeting; after reanalysis, the two researchers decided on the correct information of the extracted data.

7. CONCLUSIONS

The use of machine learning models in mass property appraisal has been progressing towards becoming a mature research area, as evidenced by the growing number of publications on the subject in scientific journals and conferences in recent years. This trend has led to a gradual increase in the body of knowledge on the topic. However, to date, no systematic literature mapping has been identified that systematically identifies and analyzes the state of the art in this research area. This study sought to fill this gap and provide an overview of the latest research using tree-based machine learning models in mass property appraisal for tax purposes.

Delving into the realm of mass property appraisal through the use of machine learning models revealed a simultaneously intriguing and complex landscape. This study, by meticulously investigating the available literature, not only highlights the popularity and efficiency of certain models, such as Random Forest and Gradient Boosting, but also points to the urgent need for the standardization and rigorous application of these technologies. Despite the revolutionary promises of precision and efficiency in property valuation for tax purposes, significant challenges remain to be overcome.

For starters, the wide range of criteria used to measure the accuracy of these models reveals the absence of a consensus or standardized system that allows for direct comparisons. While this situation showcases the richness of methodological approaches, it may complicate the clear presentation of results and, ultimately, the adoption of these technologies by tax authorities and appraisers.

Moreover, the geographical concentration of research in certain regions suggests the influence of local factors, both in terms of available data and real estate market idiosyncrasies, on the effectiveness of machine learning models. This raises questions about the universal applicability of these solutions and emphasizes the importance of future research that takes into account diversity in mass property appraisal for tax purposes.

Although models like Random Forest are notable for their robustness and accuracy, it is crucial to remember that technology alone is not a panacea. The success of these models is directly dependent on the quality and comprehensiveness of the data they are fed. Therefore, the importance of rigorously collecting, processing, and analyzing data cannot be underestimated. Furthermore, in conducting mass appraisals, it is essential to consider ethical and social justice issues, especially in relation to tax equity, an important aspect that should not be overlooked.

This study unveils a field rich in opportunities for research and innovation at the intersection of machine learning and mass property appraisal for tax purposes. The critical approach adopted here does not seek to diminish the transformative value of these technologies, but rather to underscore the complexity and responsibilities involved in their implementation. The future, filled with possibilities and challenges, demands ongoing collaboration between academics, professionals, and policy makers to ensure that technological advancements promote fairer, transparent, and effective appraisal practices.

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Influence of a traditional flea market on property prices in its surroundings – a case study in Porto Alegre, Brazil

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Abstract. Flea markets are important as economic and cultural phenomenon in several cities around the world. There is little attention to their influence on real estate prices. The "Brique da Redenção" occur every weekend since 1978 in Porto Alegre, Brazil. There could be positive effects on surrounding properties. However, the positioning of this flea market implies on reduce the accessibility on weekends to properties placed in the same street and it could reduce property prices. The aim of this paper is to evaluate the influence of this flea market in residential prices. It was developed hedonic models to explore these effects, with a sample of more than 5.3 thousand apartment sales. The analysis shows a satisfactory statistical performance of the hedonic model. The study indicates that Brique' effect is capitalized in the market prices, with an average loss on value around to 7.8% to properties placed in front to the Brique.

Keywords: Flea market, property prices, hedonic models, Brique da Redenção.
JEL codes: C15, C31, C51, R31.

1. INTRODUCTION

Flea markets are known and valued around the world. They have influence on local daily commerce and could attract a larger audience, with a tourist flow, and it have evolved into dynamic hubs of economic activity, social interaction, and cultural heritage preservation. Beyond being spaces for commerce, flea markets serve as cultural landmarks where artisans, collectors, and entrepreneurs exhibit their talents and passions. In some cases, they became landmarks of the city. For instance, there are notable flea markets in London, Paris, Rome, and Buenos Aires.

Historically, flea markets have origins from places designed to general sales as ancient Greek' Agora, Roman' Piazza and Islamic' Bazaar or Souks, which have similar characteristics (Alhazmi, 2013). The word Bazar, an alternative term to flea market, have also ancient origins. After Alhazmi (2013), the term "bazaar" finds its roots in the Persian word "baha-char", denoting a "place of prices". Evolving from its origin as "bazaar", it gained widespread

popularity across the Middle East and southern Asia.

Along time, flea markets have adapted to changing societal and economic conditions, reflecting shifts in consumer preferences, technological advancements, and urban development. From traditional open-air bazaars to modern indoor marketplaces, flea markets have maintained their relevance by embracing innovation while preserving their core principles of affordability, accessibility, and diversity (Alhazmi, 2013).

In contemporary times, flea markets emerged as venues where individuals could barter and trade goods, often secondhand, surplus items, and food, outside the confines of formal retail establishments. These markets provided a platform for people from diverse socio-economic backgrounds to engage in commerce, promoting a sense of community and facilitating the exchange of goods and ideas.

In city scale, the topic of flea markets holds significant relevance for urban development strategies and policies due to their multifaceted contributions to the socio-economic fabric of cities. Flea markets serve as dynamic spaces that can foster inclusive growth, instigate entrepreneurship, preserve cultural heritage, and enhance community resilience. Flea markets often occupy underutilized urban spaces, such as vacant lots or abandoned buildings, breathing new life into neglected areas and contributing to urban revitalization efforts. By activating these spaces, flea markets can stimulate economic activity, attract foot traffic, and catalyze further investment in surrounding neighborhoods.

Flea markets provide opportunities for small-scale entrepreneurs and artisans to start and grow their businesses, thus fostering local economic development. These markets serve as incubators for entrepreneurship, allowing individuals with limited resources to reach a wider audience without the overhead costs associated with traditional retail spaces. Moreover, flea markets contribute to job creation by supporting a diverse ecosystem of vendors, artisans, service providers, and support staff. These markets offer flexible employment opportunities, particularly for marginalized communities and individuals with limited access to formal employment sectors, thus advancing in social inclusivity and economic empowerment. Furthermore, flea markets play a crucial role in sustainable consumption practices by incentivizing recycling, repurposing, and upcycling of goods. By giving new life to preowned goods and reducing waste, flea markets contribute to reducing waste and minimizing environmental impact, and support efforts to create more resilient and resource-efficient cities.

The positive effects of the Brique are well explored in the literature on cultural, tourism and leisure aspects, as well as issues related to the informal or social economy (Abrahão, 1997b). They include a relative advantage to surrounding properties due small walking distances to access the Brique. But there are also potentially negative aspects, not yet explored. The street where it occurs is partially blocked during the daytime, and there are an intense flow of people and noise increase on daytime. So, the residents of the buildings on the same street experience some difficulties for two days a week, throughout the year.

In Porto Alegre, the best-known flea market is the "Brique da Redenção", which has been happening for 40 years, every Sunday. The Brique takes place outdoors on the José Bonifácio avenue, being assembled on Sunday mornings and dismantled in the late afternoon (Abrahão, 1997a). The Brique offers dozens of handicrafts, food, and antique options (Figure 1). There is a great flow of people (it is estimated at 50 thousand people per weekend). Whereas currently known as the Sunday' Brique da Redenção, the space appointed to this flea market is composed by several activities on the weekend. There are a set of activities on Saturdays, using the same street, in similar conditions of working. Thereafter, we will reference the effect of these weekend activities as the "Brique' effect". Given that Brique has been around for a considerable time, the local market probably has absorbed the effects and capitalized on prices, whether they are positive or negative externalities (valuing or devaluing factors). The positive effects are manifested by the accessibility on foot (distance to the Brique) in relation to the buildings situated in the surroundings. It is possible to consider that any loss of value for the properties placed in the same street will be represented by a decrease in market prices in relation to comparable properties situated in the same region. The article aims to examine the effects of Brique on the prices of apartments in the region. It uses hedonic pricing models in different configurations, exploring alternative models.

This paper is structured as follows: the subsequent section provides a literature review focusing on flea markets and hedonic studies. Section 3 outlines the case study, followed by Section 4 detailing the methodology employed. Section 5 presents the results obtained from the study, which are then discussed in Section 6. Finally, conclusions drawn from the findings are presented along with the references.

2. LITERATURE REVIEW

2.1. Flea markets

A flea market (also known as outdoor bazaar) is a space to an almost informal commerce. It is com-

mon combine antiquaries, artists, and food. The historic roots are in the Middle Ages street markets. They are attractive to residents and tourists, associating the cultural diversity, the offer of various products and a direct contact with a local street atmosphere. This economic space promotes the sales of second-hand goods, bargains, collectibles, and rare items. Other vendors offer food options, including local production with a new tendency to present sustainable and healthy products. The flea market could be organized by public or private entrepreneurs, in open or closed spaces (Ferreira et al., 2015; Olavarrieta et al., 2008; Stillerman, 2015).

There are examples in several countries and cities, and some of them are listed as World Heritage sites. In London could be cited the Borough Market, Camden Lock, Portobello Market, and Brick Lane Market. In Paris the best known is the Marche aux Puces de Saint-Ouen (Gravari-Barbas and Jacquot, 2019; http://expressoparis.com/o-mercado-das-pulgas-de-saint-ouen/; https://www.conexaoparis.com.br/2007/05/23/mercado-das-pulgas-de-saint-ouen/). Other remarkable fairs occur in Oporto, Rome (Piazza Navona), Siena (Piazza Del Campo), Venice (Piazza San Marco), Budapest, Buenos Aires (Santelmo' Fair), and Montevideo (the Praça da Matriz' Fair) (Alhazmi, 2013; Clough Marinaro, 2019; Pinho and Rocha, 2020; Várnai, 2018).

However, it was not found studies about a flea market influencing property prices. There are some examples about the influence of other kind of business activities, such as medium retail services (such as a bar or restaurant) or large retail stores (sometimes called a "bigbox") increasing values in the neighborhood (Caceres and Geoghegan, 2017; Clark et al., 2021; Daunfeldt et al., 2021; Kuang, 2017; Pope and Pope, 2015). In a broader view, it is common to verify the influence of the city centers (commercial business district – CBD), shopping centers, or secondary centers upon property prices (Ball, 1973; Des Rosiers et al., 1996, 2008; Din et al., 2001; Kryvobokov, 2007; Sirpal, 1994; Zhang et al., 2020).

Likewise, the economic influence of an urban park and other environmental amenities were studied by several authors, and in general the proximity of these elements increases the market price (Boyle and Kiel, 2001; Breunig et al., 2019; Dehring and Dunse, 2006; Din et al., 2001; Hoover et al., 2020; Morancho, 2003; Panduro and Veie, 2013; Sander et al., 2010; Saphores and Li, 2012; Schläpfer et al., 2015; Waltert and Schläpfer, 2010; Wu and Rowe, 2022; Xiao et al., 2019; Yuan et al., 2020). In these studies, it's a common choice to verify walking and cycling distances between 0.5 and 3 km.

2.1. Hedonic price modelling

The referenced studies are based on hedonic price modelling (HPM). Hedonic models are well known and used for different kind of market studies. They consist of a model or equation, in which price is the dependent variable and the explanations proposed are the independent variables. The coefficients stand for the relative importance of each variable included in the model (their contribution to the price definition). Models are usually calculated through multiple regression. The literature reveals a great diversity of models, with different variables and formats to the hedonic equations (Agarwal et al., 2021; Ball, 1973; Beracha and Hardin, 2021; Boyle and Kiel, 2001; Din et al., 2001; Dokmeci et al., 2002; Francke and Van de Minne, 2021; Halvorsen and Pollakowski, 1981; Helbich et al., 2014; Kryvobokov, 2007; Morancho, 2003; Schläpfer et al., 2015; Waltert and Schläpfer, 2010).

Because the main goal in this work is to explore economic issues, HPM are used because deal with property prices. In HPM, the value of a property correlates with its utility, gauged through a quality index. Market participants evaluate some factors such as the physical characteristics of the property, its spatial context (location), and prevailing market conditions (Eq.1).

$$\text{Price} = f(\text{physical attributes, location, market conditions}) \quad (1)$$

Physical attributes encompass the defining features of the property, such as its dimensions, room count, construction quality, and age. The location dimension considers factors like accessibility and neighborhood desirability, highlighting the spatial stability of the property. Market conditions include prevailing social and cultural preferences, economic circumstances, and transaction specifics, including payment modalities, interest rates, and timing of sale.

Creating numerical models for the real estate market is advantageous. Given the diverse characteristics of properties, it's essential to consider multiple attributes concurrently, each assigned varying importance in determining prices for different property types. Hence, it's typical to construct models tailored to specific segments, such as land, residential homes, or commercial properties. The theoretical underpinning for price modeling lies in the hedonic pricing theory (Rosen, 1974; Sheppard, 1999).

A hedonic price model depicts the price as a function of property attributes (Equation 2). However, these attributes are not directly valued, and the connection

between attributes and property prices can be viewed as indirect or implicit prices (Rosen, 1974):

$$\text{Price} = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \cdots + \beta_k x_k + \varepsilon \quad (2)$$

Where Price is the studied or dependent variable; the $x_1, \ldots, x_k$ are the independent, explanatory variables (representing k attributes); $\beta_0, \ldots, \beta_k$ are the coefficients of the equation (the implicit prices), and ε is the error term.

It is common to accept that models are generated empirically by exploiting market data (data-driven models). Models and variables are analyzed according to conventional statistical tests and must reach a predetermined level of confidence to be accepted. The analysis process includes the collection of data relevant to the problem under study, the proposition of a model (relationship hypothesis according to the analyst's knowledge about the phenomenon or market segment under analysis), modelling and testing of the model. Satisfying statistical requirements, the final model could be used to obtain conclusions about the market (an inference process).

Indeed, the aim is to construct a numerical model that elucidates connections and predicts values. In the conventional approach, coefficients are derived through multiple regression analysis (MRA). Several conditions (assumptions) need to be verified to ensure the robustness of the regression model. These include homoscedasticity, linearity of the relationship in (Equation 2), absence of perfect multicollinearity (particularly with multiple explanatory variables), lack of serial or spatial correlation, and no significant unexplained errors (outliers). If any of these statistical issues arise, the model's effectiveness diminishes or may even become invalid.

3. CASE STUDY – THE BRIQUE DA REDENÇÃO

The case study is the Brique da Redenção, placed in Porto Alegre, a southern Brazilian city. The Brique da Redenção begins in 1978. It was first called simply as a "Brique" and sometimes as "Feira Cultural do Bom Fim", presenting initially only antiquaries. In 1982, the artisans who marketed their merchandise inside the Farroupilha Park joined to the Brique, which later received an area for gastronomy and fine arts. Currently, the Brique is composed of 182 handicrafts expositors, 70 antiques, 40 of plastic arts and 10 of food products. They are selected by public competition. The Brique da Redenção is also frequented by street performers, mostly musicians who make presentations along the José Bonifácio Avenue (Figure 1).

There are a group of activities that take place on this space, on Saturdays and Sundays in the Jose Bonifacio Avenue (Table 1). They are supervised and regulated by public administration. Despite of some diversity of activities, it is known in the city as the "Brique".

The city has another 10 handicraft fairs, this being the most relevant. Due to its importance in the cultural context of the city, in 2005 a local law was passed declaring the Brique da Redenção as Cultural Heritage of the State of Rio Grande do Sul (http://briquedaredencao.com.br/institucional).

The effects of the Brique have been studied from several points of view. Among the local studies, some may be cited (Abrahão, 1997a; Cardoni, 2017; Malysz, 2013; Oliveira et al., 2012; Peciar and Isaia, 2005; Pertile, 2014; Silveira and Rocha, 2007; http://www.correiodopovo.com.br/Noticias/Geral/2017/03/613498/Brique-da-Redencao-completa-39-anos-em-grande-estilo).

In addition, one can also cite the effect of the proximity of the Farroupilha Park, which also attracts visitors. The Farroupilha Park (also known as Parque da Redenção) is neighbor to the Brique (see Figure 1). This urban park has 375,000 m^2 and it is a reference point to the city. In that local occurred an International Fair in the beginning of XX century (the Great Exhibition on 1901) and by now the park is consolidated as a sports and leisure space. It regularly attracts many visitants (Caccia, 2011; Lima, 2016; Melo and Dias, 2014; Pimentel et al., 2016; Rosa and Rocha, 2004; Stigger et al. 2010).

4. RESEARCH METHOD

The investigation on the Brique flea market' effect on property prices was based on hedonic model-ling. In this case, the main issue is to verify the influence of the Brique on residential property prices. To investigate these effects, it was collected a sample from apartments, selecting cases in regions around to the Brique. It was used apartments because the region is majority occupied by vertical buildings. Data was collected in local broker's sites and complemented with additional information, described in sequence. The attributes investigated are common in local market.

It was collected in broker's site information about price, size, number of bedrooms and parking spaces. Price was converted to Euros, concerning the exchange rate of the information date, Month, which uses a continuous scale of time, beginning on the month of the oldest case in the sample (January 2020 = 1) and ending in the last ones (December 2022 = 36).

Using the address, building quality and year of building completion were collected in municipal register. They are official information.

Figure 1. Images of a regular weekend - Saturdays and Sundays. Source: Author.

Table 1. Regular activities in the region of the Brique da Redenção on weekends.

Activities	Kind	Local	Weekday and time
Brique da Redenção	handicraft, food, and antique options	José Bonifácio Avenue	Sundays, 9 to 18h
Brique de Sábado **(Saturday' Brique)**	food, and antique options	José Bonifácio Avenue (among João Pessoa Avenue and Vieira de Castro street)	Saturdays, 9 to 17h
Feira de Artesanato do Brique de Sábado	handicraft	José Bonifácio Avenue (among Vieira de Castro and Santa Teresinha streets)	Saturdays, 14 to 18h
Feira Ecológica	ecological food	José Bonifácio Avenue	Saturdays, 7 to 13h

Source: Cardoni (2017); http://www2.portoalegre.rs.gov.br/smic/default.php?p_secao=206 and http://www2.portoalegre.rs.gov.br/smic/default.php?p_secao=200

In terms of location, it was used a conventional variable of neighborhood, District, defined according to author's experience in local market. The distances to the urban parks and large commerce points were calculated as straight lines, using coordinates associated to each apartment. Distance to commerce was calculates to the nearest element of commerce (CBD, shopping malls and supermarkets). The reference point to CBD is the centenary Public Market, placed in the historic center of the city and near the Guaíba River. Location of supermarkets and shopping malls identified in the region in study was recorded (Table 2). The region also has the important pres-

Table 2. Characterization of Variable' set.

Attribute	Description	Unity	Range	Average	Correlation with Price
Price	Total Price	Euros	83,040.00-894,839.50	436,981.06	-
Surface	Private area of property	m^2	24.31-389.56	111.81	0.796
Bedroom	Number of bedrooms	-	1-4	2.66	0.639
Parking	Number of parking spaces	-	0-3	0.97	0.166
Standard	Level of building quality	-	2-10	7.05	0.420
Year	Year of building completion	year	1946-2018	1,977.30	0.366
Month	Information' time, in a continuous scale: Month=1: Jan 2020; Month=36: Dec 2022	month	1-36	2.20	0.118
District	General quality of district as based on Author's experience	-	20 - 60	42.58	0.307
Commerce	Shortest distance to a large commerce point	km	0.024 - 1.86	0.468	-0.010
Parks	Shortest distance to an urban park	km	0.040 - 3.54	1.248	-0.123
Dist.Brique	Distance to the Brique	km	0.032 - 3.02	1.381	0.061
ifB	Property placed in front to the Brique	-	0 - 1	0.0175	-0.036
Same.Block	Property placed in other sides of blocks with properties with *ifB*=1	-	0 - 1	0.0075	0.011

Source: Data collection by the Authors.

ence of two urban parks, Farroupilha and Moinhos de Vento, which are symbols of leisure in the city and receive a large number of people throughout the week. Distance to the nearest park also was calculated choosing the nearest one in each case of sample (Table 2 and Figure 2-right).

Properties placed in the José Bonifácio Avenue were marked through a binary variable (ifB = 1 to property placed in front to the Brique, and 0 otherwise). There are 114 cases of apartments placed in the José Bonifácio Avenue in the sample (2.1% of total of cases).

As a control mechanism, it was defined Same. block, a binary variable identifying properties placed in the same blocks of ifB cases, but in one of the other three sides. These properties are very close to the Brique (100m or less), but do not have the negative effects investigated (noise, access reduction, and others). There are 49 cases of this situation.

It was also calculated the distance from properties to the Brique. As the Brique space is a linear element (it is a street with 700 m – see Figure 2), it was used three reference points to calculate the distances, in the start, middle and the end of this street. The distance to the Brique was calculated as the shortest distances to these points. The distance was measured as a straight line (Table 2).

After regular procedures of cleaning and including additional information, the final sample used to develop the models has 5,378 cases. The sample was shared in two parts to allow a cross-validation, a modelling sample with 70%, and a sample reserved to test the model, not used in the modelling process (with 30%). The analysis in modelling stage was based in R2 (coefficient of determination), F and t analysis, outlier detection. RMSE (root mean squared error) values were used to compare the results to training and testing sub-samples. Also was developed spatial analysis using Moran's I to verify the presence of spatial correlation. Figure 2 presents the sample (training and test cases), commerce points, parks and cases of ifB and Same.Block. Besides the two parks, some larger spaces with no properties could be viewed on the image. They are public buildings, such as hospitals or university, and office buildings.

Cases on sample are placed at 3 km or lower distance to the Brique (Table 2). This distance is consistent with the on-site observation of users walking or riding a bike to the Brique, that is, great part of the users probably lives on the surroundings. Evidence of this view is the small parking space available in the region, although there are reports that there are users from other districts and cities.

5. RESULTS

Several models were explored in the modelling process, with different attribute' sets and alternative model formats. In terms of dependent variable, it was tested hedonic models using Price in the linear and logarithmic formats, and Price as a unitary value (Euros/m^2). Despite satisfactory performance of some of them, the log-linear model revealed better results.

The process includes examination of some attributes and outlier' removal. Final model has maximum

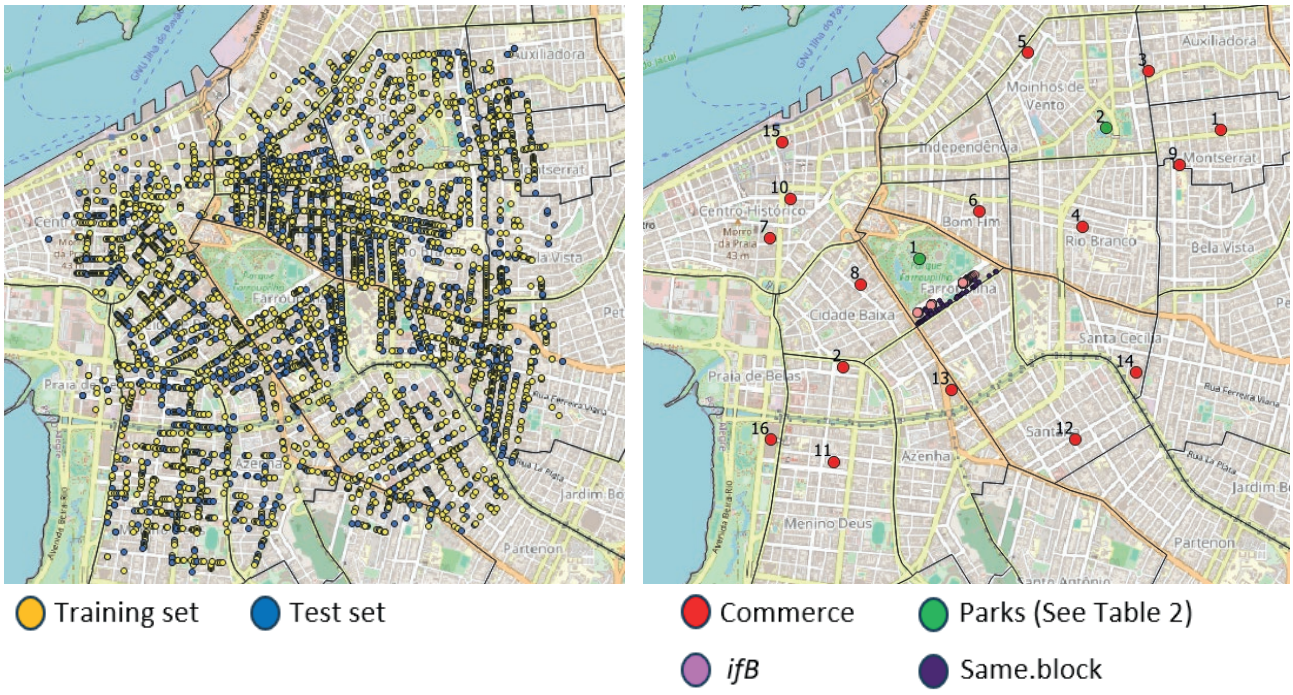

Figure 2. Region under study: sample positioning (left) and schematic placement of variables Commerce, Parks, i*f*B and Same.block (right). Source: Author.

errors in the +/-3 standard deviations. Spatial analysis was developed through Moran's I. The calculated value is I = 0.0625, using a k-NN, with an inverse squared distance scheme. In this case, spatial autocorrelation could be discarded.

The set of variables presented in Table 2 was investigated. It was analyzed some numeric transformations on the distance variables, using direct, inverse, squared inverse, square root, and logarithmic formats, with linear showing the best results. Variables Same.Block and Dist.Brique were not significant and then were not included on final model, both with large error level.

The model presented on Table 3 is the model with best general statistical performance. Log-linear regression model to total price achieve R^2=0.7705. All the attributes included in the model are significant at α = 0.01 level. Actually, the p-values are small to all of them. The Fisher-Snedecor variance test to the model (F_{calc}=1,260.289). also shows a low error level, around zero in this case.

The validity of the model (Table 3) was analyzed by conventional tests (F for the model, t for variables, outliers, normality of residues, among others). In addition, a cross-validation mechanism was employed, by putting aside a 30% sample to test the model. The model was used to estimate the values for the test sample data, calculating the RMSE error statistic (Table 3). The ratio between them shows an increase of 1.04% on the error level, as measured by RMSE. They could be considered as minor differences. The similarity of the

Table 3. Results of the hedonic model.

Attribute	Coefficient (p-value) *
Intersection	2.034984 (<0.001)
Surface	0.005339 (<0.001)
Bedrooms	0.064560 (<0.001)
Parking Spaces	0.165513 (<0.001)
Building standard	0.052864 (<0.001)
Year	0.003832 (<0.001)
Month	0.021034 (<0.001)
District	0.005860 (<0.001)
Commerce	-0.038961 (0.005842)
Park	-0.027167 (<0.001)
ifB	-0.078581 (0.001446)
R^2	0.7705
Moran's I	0.0625
RMSE to training sample (3,765 cases)	18,891
RMSE to test sample (1,613 cases)	19,088 (+1.04%)

Note: The dependent variable is the natural log of price (ln Price). *all significant at the 1% level.

errors between error figures on Table 3 model and values calculated to the sample test shows that the adjusted model is consistent with available data of market segment in study.

6. DISCUSSION OF THE RESULTS

In a first view the model is coherent with local real estate market and have satisfactory statistical performance. The set of regular building attributes, such as number of Bedrooms, Parking spaces, and Building quality is important in statistical terms, as expected (Table 3). Given it's a semi-log model, coefficients could be interpreted as the contribution of each variable on the price. In this case, in-crease 1m² in Surface make grow an average of 0.053% on Price, while one more Bedroom increases 6.45% and one Parking space has even greater influence, reaching 16.5% of average Price.

Location attributes, as District and distances to Commerce and Parks also are relevant. Beside Mo-ran's I results, it could be concluded location effects are consistently considered in the model (Table 3). The significance of access to regular commerce was detected. The coefficient could be interpreted as an average penalty on price of 3.9% when distance to nearest commerce point increases 1 km. In the same way, distance to the parks shows a price fall of 2.7% by kilometer.

More attention is given in sequence to ifB. After the conventional regression tests upon ifB, this variable has satisfactory statistical performance (as the p-value is 0.00145). The adjusted model shows the existence of a tendency to reduce prices in 7.8% for a property placed directly in the José Bonifácio Avenue (Table 3). In monetary terms, the loss on value it is greater than the influence of one Bedroom (6.46%), or 14 square meters in building surface.

By another side, Same.Block was really not statistically significant. One could conclude there are no significant difference among these properties and the others. In another words, small distance to the Brique is not an inconvenience, only if the property is in front.

Indeed, the model constructed from the collected data shown a loss of value, which can be interpret-ed as an effect of the Brique, since equivalent properties placed in the surroundings and, more specifically, several buildings found in the other side of same blocks, do not present this loss. One could explain this flea' effect by the reduction on building accessibility, noise, or an "excessive" movement of people in property' buyers view.

7. CONCLUSION

The topic of flea markets demonstrates relevance for urban development strategies and policies by offering solutions to various challenges faced by cities, including economic stagnation, social exclusion, cultural homogenization, and environmental degradation. By recognizing the potential of flea markets as catalysts for positive change, urban planners and policymakers can harness their unique attributes to create more inclusive, vibrant, and sustainable cities for all residents. In essence, flea markets represent more than just a marketplace; it embodies a rich scenery of history, culture, and commerce. As one delves deeper into understanding the contextualization of flea markets, more uncover the intricate interplay between economic forces, social dynamics, and cultural heritage, highlighting their enduring significance in today's globalized world.

It was presented a hedonic study about the influence of a Porto Alegre flea market on real estate prices of surrounding properties. This flea market, which is known as "Brique da Redenção", has happened for more than 40 years. The placement of the Brique on the street on every weekend reduces relative to the accessibility of some buildings by two days a week, as its difficult to use vehicle and access freely the building in the period of Brique working.

The studied hedonic price models include a dichotomic variable to compare "adversely affected" (properties placed in front to the Brique). The results of statistical analysis shown the existence of adverse flea-effects. The ifB hedonic coefficient indicates an average reduction of about 7.8% on prices to in front properties.

It could be concluded these results shown influences of Brique on apartment prices. While it could appear unfair to owners of these buildings, considering the long time in which the flea market takes place in the same point, this effect it is capitalized on market prices, and it is not a surprise to new buyers, while could be to long-time owners.

The study presents, to the best of our knowledge, the first examination of the consequences of a flea market on surrounding property prices. The Brique holds historic, cultural, social, and economic significance, so the findings presented in this work should not be perceived as threats to the preservation of its activities. While the Brique is important to many people, it may also result in losses for some property owners, which could be considered unfair. The results presented here serve to underscore this issue and prompt the establishment of specific regulations to address it. For example, proposing a reduction in property taxes or sales taxes for affected owners,

proportional to their economic losses. Following national law, affected owners could pursue legal action for compensation; however, this process entails costs and typically involves a lengthy period before a decision is reached.

This study deals with the dynamics of the property market, aiming to provide insights into its intricacies. However, it is essential to acknowledge the limitations inherent in the research process. One such limitation revolves around the source of data utilized in this study. While every effort has been made to ensure the accuracy and reliability of the data, it is crucial to recognize that data collection methodologies may have inherent biases or limitations. Additionally, the scope of available data may restrict the comprehensiveness of the analysis. Despite these constraints, the study endeavors to offer valuable perspectives on the property market landscape. Future research endeavors could benefit from addressing these limitations by employing diverse data sources or refining data collection methodologies to enhance the robustness of findings. Overall, by transparently acknowledging these limitations, this study aims to contribute meaningfully to the broader discourse surrounding property market dynamics and inform stakeholders about potential considerations in interpreting the results.

Future investigation could include ethnographic observations and supplemental semi-structured surveys with vendors, users, and property owners, looking for personal view of advantages and disadvantages, and also the distance from their homes to Brique and access methods. Despite of promising results derived of these studies, there are practical issues. In Brazil, is mandatory to create a detailed research protocol, which need be approved before to develop interviews. Due to large audience enrolled, it's difficult. Another question is the cost of this kind of research. To be relevant in statistical terms, interviews need be developed considering probable differences on people's view after their economic and social status, role played, time of frequenting Brique, and so on. Furthermore, it could contribute to understand causes and reasons to the influence of Brique on surrounding prices but will not directly to estimate the amount of price differences.

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a cura di Nicola Lucifero

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AGRICOLTURA

Corte giustizia Unione Europea, Sez. VIII, 13/06/2024, C-731/22, *IJ und PO GesbR, IJ contro Agrarmarkt Austria,*
Agricoltura – Politica agricola comune (PAC) – Regimi di sostegno – Pagamenti diretti agli agricoltori – Regolamento (UE) n. 1307/2013 – Articolo 4, paragrafo 1, lettere b) e c) – Nozione di "azienda" – Gestione da parte di un agricoltore – Nozione di "attività agricola" – Articolo 33, paragrafo 1 – Nozione di "superficie agricola a disposizione dell'agricoltore alla data fissata dallo Stato membro", ai fini dell'attivazione dei diritti all'aiuto – Cessione stagionale, dietro corrispettivo, delle parcelle di un terreno di proprietà dell'agricoltore a utilizzatori che si incaricano della manutenzione di tali parcelle e della raccolta
Il combinato disposto dell'articolo 4, paragrafo 1, lettere b) e c), e dell'articolo 33, paragrafo 1, del regolamento (UE) n. 1307/2013 del Parlamento europeo e del Consiglio, del 17 dicembre 2013, recante norme sui pagamenti diretti agli agricoltori nell'ambito dei regimi di sostegno previsti dalla politica agricola comune e che abroga il regolamento (CE) n. 637/2008 del Consiglio e il regolamento (CE) n. 73/2009 del Consiglio, deve essere interpretato nel senso che esso non osta a che un agricoltore riceva i pagamenti diretti di cui all'articolo 1, lettera a), di tale regolamento per una superficie di sua proprietà e a che tale superficie sia qualificata come «azienda gestita» da tale agricoltore e «a disposizione» di quest'ultimo, qualora, da un lato, le parcelle che compongono detta superficie siano cedute a utilizzatori scelti dal suddetto agricoltore i quali, dietro versamento di un corrispettivo fisso, si incaricano della manutenzione di tali parcelle e della raccolta, e, dall'altro, lo stesso agricoltore, senza avere alcun diritto sui risultati di questo lavoro, si occupi della lavorazione iniziale del terreno, della coltivazione e dell'irrigazione corrente di dette parcelle, o anche della loro manutenzione se gli utilizzatori non lo fanno.

Corte giustizia Unione Europea, Sez. III, 25/04/2024, C-309-310/23, *Pesticide Action Network Europe (PAN Europe) contro College voor de toelating van gewasbeschermingsmiddelen en biociden*
Regolamento (CE) n. 1107/2009 – Autorizzazione d'immissione sul mercato dei prodotti fitosanitari – Esame ai fini dell'autorizzazione – Articolo 4 – Articolo 29 – Requisiti – Assenza di effetto nocivo – Criteri – Pro-

prietà d'interferente endocrino – Regolamento (UE) 2018/605 – Principio di precauzione – Conoscenze scientifiche e tecniche attuali

L'articolo 29, paragrafo 1, lettere a) ed e), nonché l'articolo 4, paragrafo 1, secondo comma, e paragrafo 3, del regolamento (CE) n. 1107/2009, del Parlamento europeo e del Consiglio, del 21 ottobre 2009, relativo all'immissione sul mercato dei prodotti fitosanitari e che abroga le direttive del Consiglio 79/117/CEE e 91/414/CEE, come modificato dal regolamento (UE) 2018/605 della Commissione, del 19 aprile 2018, che modifica l'allegato II [a] l regolamento (CE) n. 1107/2009 stabilendo criteri scientifici per la determinazione delle proprietà di interferente endocrino, in combinato disposto con il punto 3.6.5 dell'allegato II al regolamento n. 1107/2009, come modificato, devono essere interpretati nel senso che l'autorità competente di uno Stato membro incaricata di valutare una domanda di autorizzazione d'immissione sul mercato di un prodotto fitosanitario è tenuta, in sede d'esame di tale domanda, a prendere in considerazione gli effetti indesiderati che le proprietà d'interferente endocrino di una sostanza attiva contenuta in detto prodotto possono causare all'essere umano, tenuto conto delle conoscenze scientifiche o tecniche pertinenti e attendibili che sono disponibili al momento di tale esame e che sono, segnatamente, riportate nei criteri enunciati in tale punto 3.6.5.

Corte giustizia Unione Europea, Sez. III, 25/04/2024, C-308/23, *Pesticide Action Network Europe (PAN Europe) contro College voor de toelating van gewasbeschermingsmiddelen en biociden*

Regolamento (CE) n. 1107/2009 – Autorizzazione d'immissione sul mercato dei prodotti fitosanitari – Esame ai fini dell'autorizzazione – Articolo 36 – Margine di discrezionalità dello Stato membro interessato, ai sensi dell'articolo 36, paragrafo 2, relativo alla valutazione scientifica dei rischi effettuata dallo Stato membro che esamina la domanda di autorizzazione a norma dell'articolo 36, paragrafo 1 – Articolo 44 – Revoca o modifica di un'autorizzazione – Principio di precauzione – Ricorso giurisdizionale effettivo – Conoscenze scientifiche e tecniche attuali

1) L'articolo 36 del regolamento (CE) n. 1107/2009 del Parlamento europeo e del Consiglio, del 21 ottobre 2009, relativo all'immissione sul mercato dei prodotti fitosanitari e che abroga le direttive del Consiglio 79/117/CEE e 91/414/CEE del Consiglio, deve essere interpretato nel senso che lo Stato membro che adotta una decisione riguardante l'autorizzazione d'immissione sul mercato di un prodotto fitosanitario, ai sensi dell'articolo 36, paragrafo 2, di tale regolamento, può discostarsi dalla valutazione scientifica dei rischi riguardanti tale prodotto realizzata dallo Stato membro che esamina la domanda di una siffatta autorizzazione, ai sensi dell'articolo 36, paragrafo 1, di detto regolamento, nelle ipotesi di cui all'articolo 36, paragrafo 3, secondo comma, del medesimo regolamento, segnatamente quando dispone dei dati scientifici o tecnici più attendibili, di cui tale ultimo Stato membro non ha tenuto conto nel preparare la sua valutazione, che individuano un rischio inaccettabile per la salute umana o animale o per l'ambiente.

2) L'articolo 36 del regolamento n. 1107/2009, letto alla luce del principio di tutela giurisdizionale effettiva, deve essere interpretato nel senso che le conclusioni della valutazione realizzata dallo Stato membro competente in forza dell'articolo 36, paragrafo 1, di tale regolamento possono essere prese in considerazione dal giudice dello Stato membro interessato, ai sensi dell'articolo 36, paragrafo 2, di detto regolamento, che è chiamato a pronunciarsi sulla legittimità di una decisione adottata ai sensi dell'articolo 36, paragrafi 2 o 3, del medesimo regolamento, alla luce delle condizioni sostanziali e procedurali previste da tali disposizioni, fermo restando che tale giudice non può sostituire la propria valutazione degli elementi fattuali di carattere scientifico e tecnico a quella delle autorità nazionali competenti.

3) L'articolo 36, paragrafi 2 e 3, del regolamento n. 1107/2009 deve essere interpretato nel senso che qualora lo Stato membro che adotta una decisione riguardante l'autorizzazione d'immissione sul mercato di un prodotto fitosanitario ai sensi di tali disposizioni ritenga che la valutazione scientifica dei rischi realizzata dallo Stato membro che esamina la domanda ai sensi dell'articolo 36, paragrafo 1, di tale regolamento sia insufficientemente motivata rispetto alle sue preoccupazioni relative alla salute umana o animale o all'ambiente, in relazione alle condizioni ambientali o agricole specifiche del suo territorio, esso non è tenuto ad associare quest'ultimo Stato membro alla realizzazione di una nuova valutazione sulla base della quale l'autorizzazione d'immissione sul mercato del prodotto fitosanitario possa essere adottata.

4) L'articolo 29, paragrafo 1, lettera e), e l'articolo 36, paragrafo 2, del regolamento n. 1107/2009 devono essere interpretati nel senso che al fine di contestare l'autorizzazione di un prodotto fitosanitario nel territorio dello Stato membro che adotta una decisione riguardante una tale autorizzazione ai sensi di quest'ultima disposizione, è possibile addurre dinanzi alle autorità o ai giudici di tale Stato membro i dati scientifici o tecnici disponibili più attendibili, al fine di dimostrare che la valutazione scientifica dei rischi realizzata dallo Stato membro che esamina la domanda ai sensi dell'articolo 36, paragrafo

1, di tale regolamento, riguardante detto prodotto fitosanitario, è insufficientemente motivata.

Corte giustizia Unione Europea, Sez. VII, 18/04/2024, C-79/23, *FJ contro Agrárminiszter*
Rinvio pregiudiziale – Agricoltura – Politica agricola comune – Regimi di sostegno diretto agli agricoltori – Regolamento (CE) n. 1122/2009 – Regime di pagamento unico per superficie – Articolo 58 – Riduzioni ed esclusioni applicabili in caso di dichiarazione eccessiva – Sanzione in caso di dichiarazione eccessiva superiore al 50% della superficie determinata – Recupero dell'importo della sanzione nel corso dei tre anni civili successivi all'anno civile dell'accertamento – Nozione di "accertamento" – Relazione di controllo che accerta l'esistenza di irregolarità nella domanda di aiuto interessata
L'articolo 58, terzo comma, del regolamento (CE) n. 1122/2009 della Commissione, del 30 novembre 2009, recante modalità di applicazione del regolamento (CE) n. 73/2009 del Consiglio per quanto riguarda la condizionalità, la modulazione e il sistema integrato di gestione e di controllo nell'ambito dei regimi di sostegno diretto agli agricoltori di cui al medesimo regolamento e modalità di applicazione del regolamento (CE) n. 1234/2007 del Consiglio per quanto riguarda la condizionalità nell'ambito del regime di sostegno per il settore vitivinicolo, come modificato dal regolamento di esecuzione (UE) n. 1368/2011 della Commissione, del 21 dicembre 2011, dev'essere interpretato nel senso che la nozione di «accertamento», ai sensi di tale disposizione, riguarda, nell'ipotesi in cui l'agricoltore sia stato oggetto di un controllo *in loco*, la relazione di controllo redatta a seguito di tale controllo e che accerta l'esistenza di irregolarità nella domanda di aiuto di cui trattasi.

Corte giustizia Unione Europea, Sez. VII, 21/03/2024, C-7/23, *Marvesa Rotterdam NV contro Federaal Agentschap voor de veiligheid van de voedselketen (FAVV)*
Rinvio pregiudiziale – Agricoltura – Ravvicinamento delle legislazioni sanitarie – Polizia sanitaria – Controlli veterinari – Prodotti di origine animale importati dalla Cina – Divieto di importazione – Decisione 2002/994/CE – Esenzione per alcuni prodotti – Parte I dell'allegato – Prodotti della pesca – Nozione – Olio di pesce – Prodotti destinati all'alimentazione animale – Validità
La parte I dell'allegato della decisione 2002/994/CE della Commissione, del 20 dicembre 2002, recante misure di protezione nei confronti di prodotti di origine animale importati dalla Cina, quale modificata dalla decisione di esecuzione (UE) 2015/1068 della Commissione del 1° luglio 2015, deve essere interpretata nel senso che la nozione di «prodotti della pesca» comprende i prodotti destinati al consumo umano e non quelli destinati all'alimentazione animale e che, di conseguenza, l'olio di pesce destinato all'alimentazione animale non è un «prodotto della pesca» ai sensi di tale allegato.

Corte giustizia Unione Europea, Sez. I, 29/02/2024, C-437/22, *R.M., E.M. con l'intervento di Eesti Vabariik (Põllumajanduse Registrite ja Informatsiooni Amet)*
Rinvio pregiudiziale – Agricoltura – Politica agricola comune – Sostegno allo sviluppo rurale da parte del Fondo europeo agricolo per lo sviluppo rurale (FEASR) – Tutela degli interessi finanziari dell'Unione europea – Regolamento (CE, Euratom) n. 2988/95 – Articolo 7 – Misure e sanzioni amministrative – Regolamento n. 1306/2013 – Articoli 54 e 56 – Regolamento delegato n. 640/2014 – Articolo 35 – Recupero delle somme indebitamente versate presso persone che hanno partecipato all'esecuzione dell'irregolarità – Nozione di "beneficiario"
1) L'articolo 56, primo comma, del regolamento (UE) n. 1306/2013 del Parlamento europeo e del Consiglio, del 17 dicembre 2013, sul finanziamento, sulla gestione e sul monitoraggio della politica agricola comune e che abroga i regolamenti del Consiglio (CEE) n. 352/78, (CE) n. 165/94, (CE) n. 2799/98, (CE) n. 814/2000, (CE) n. 1290/2005 e (CE) n. 485/2008, letto, da un lato, in combinato disposto con l'articolo 54, paragrafo 1, di tale regolamento nonché con l'articolo 35, paragrafo 6, prima frase, del regolamento delegato (UE) n. 640/2014 della Commissione, dell'11 marzo 2014, che integra il regolamento (UE) n. 1306/2013 del Parlamento europeo e del Consiglio per quanto riguarda il sistema integrato di gestione e di controllo e le condizioni per il rifiuto o la revoca di pagamenti nonché le sanzioni amministrative applicabili ai pagamenti diretti, al sostegno allo sviluppo rurale e alla condizionalità, e, dall'altro, alla luce dell'articolo 7 del regolamento (CE, Euratom) n. 2988/95 del Consiglio, del 18 dicembre 1995, relativo alla tutela degli interessi finanziari delle Comunità, deve essere interpretato nel senso che il recupero di un aiuto finanziato dal Fondo europeo agricolo per lo sviluppo rurale e che è stato indebitamente percepito a seguito di manovre fraudolente può essere perseguito a carico non solo del beneficiario di tale aiuto, ma anche delle persone che, senza poter essere considerate beneficiarie di detto aiuto, hanno deliberatamente fornito false informazioni ai fini del suo ottenimento.
2) L'articolo 35, paragrafo 6, del regolamento delegato n. 640/2014 deve essere interpretato nel senso che nel caso

in cui una persona giuridica abbia ottenuto un aiuto agricolo a seguito di manovre fraudolente imputabili ai suoi rappresentanti, questi ultimi non possono tuttavia essere considerati «beneficiari» di tale aiuto, ai sensi di tale disposizione, in combinato disposto con l'articolo 2, paragrafo 1, secondo comma, punto 1, di tale regolamento delegato, qualora essi non rientrino in alcuna delle tre categorie di persone contemplate da quest'ultima disposizione, e ciò anche se, di fatto, sono tali rappresentanti a percepire gli utili generati da tale persona giuridica.

Cass. civ., Sez. lavoro, Ordinanza, 22/05/2024, n. 14236
Agricoltura – Lavoro – contratto a tempo determinato
L'elenco delle attività stagionali di cui al D.P.R. n. 1525 del 1963 è da considerarsi tassativo e non suscettibile di interpretazione analogica, vincolo, questo, che si riflette anche sulla contrattazione collettiva di cui all'art. 5, comma 4-ter, D.Lgs. n. 368 del 2001, la quale deve, a propria volta, elencare in modo specifico le attività caratterizzate da stagionalità. Ne consegue che la naturale ciclicità temporale dell'attività agricola non rende automaticamente il rapporto agricolo peculiare né giustifica la possibilità di proroghe e/o rinnovi oltre il termine del triennio, dal momento che neppure la ciclicità dell'attività agricola consente eccezioni alla disciplina dei contratti a termine, dovendosi invece ritenere che i lavori adibiti stabilmente a mansioni che rispondono ad esigenze permanenti dell'attività stagionale debbano essere dipendenti a tempo indeterminato.

Cass. civ., Sez. II, Ordinanza, 12/03/2024, n. 6486
Riforma fondiaria - Terreni soggetti a riforma - In genere - Immobili appartenenti ad enti di sviluppo - Destinazione ex lege a pubblico servizio - Usucapibilità - Esclusione - Trasferimento al comune - Cessazione di fatto della destinazione a pubblico servizio - Esclusione - Fondamento
I terreni appartenenti agli enti di sviluppo, in quanto destinati a un uso pubblico ex art. 1 l. n. 230 del 1950, non possono essere sottratti a tale finalità se non nei modi stabiliti dalla legge che li riguardano, ai sensi degli artt. 830, secondo comma, 828, secondo comma, c.c., con la conseguente impossibilità giuridica di una acquisizione da parte di terzi per usucapione, anche a seguito del loro trasferimento al Comune a titolo gratuito, in quanto atto non idoneo a far venire meno la suddetta destinazione.

Cass. civ., Sez. II, Ordinanza, 15/02/2024, n. 4188
Impianto di nuovo vitigno - Procedura di autorizzazione - Comunicazione della chiusura dei lavori - Obbligo - Fondamento - Conseguenze del relativo inadempimento
In tema di sanzioni amministrative, la procedura di autorizzazione di nuovo impianto di vigneti per uva da vino di derivazione eurounionale è tesa al monitoraggio del rilascio delle autorizzazioni nella complessiva misura prevista dell'1% della superficie vitata nazionale, allo scopo di garantire il perseguimento della finalità, prefissata nel Regolamento UE n. 1308/2013, di aumentare ordinatamente gli impianti viticoli attraverso uno sviluppo controllato e contingentato dei diritti all'impianto, con la conseguenza che la mancata o tardiva comunicazione alla Regione dell'avvenuta fruizione, totale o parziale, dell'autorizzazione al nuovo impianto non costituisce una mera irregolarità negli adempimenti comunicativi, ma determina il mancato completamento della fattispecie acquisitiva del diritto al nuovo impianto, ed il perfezionamento della condotta illecita, ossia la realizzazione di un nuovo impianto viticolo senza aver utilizzato l'autorizzazione.

Cons. Stato, Sez. V, 20/05/2024, n. 4478
Agricoltura – agriturismo – rapporto con le attività principali - prevalenza
L'inquadramento dell'attività agrituristica in quella agricola è subordinato alla condizione che l'utilizzazione dell'azienda agricola per fini di agriturismo sia caratterizzata da un rapporto di complementarità rispetto all'attività di coltivazione del fondo, di silvicoltura e di allevamento del bestiame, che deve rimanere principale (ovvero "prevalente").

ALIMENTI E BEVANDE

Corte giustizia Unione Europea, Sez. IX, 08/05/2024, C-216/23, *Hauser Weinimport GmbH contro Freistaat Bayern*
Rinvio pregiudiziale – Ravvicinamento delle legislazioni – Agricoltura – Definizione, designazione, presentazione, etichettatura e protezione delle indicazioni geografiche dei prodotti vitivinicoli aromatizzati – Regolamento (UE) n. 251/2014 – Articolo 3, paragrafo 4 – Cocktail aromatizzato di prodotti vitivinicoli – Definizione – Nozioni di "alcole" e di "prodotto alimentare sapido"
1) L'articolo 3, paragrafo 4, lettera c), del regolamento (UE) n. 251/2014 del Parlamento europeo e del Consiglio, del 26 febbraio 2014, concernente la definizione, la designazione, la presentazione, l'etichettatura e la protezione delle indicazioni geografiche dei prodotti vitivinicoli aromatizzati e che abroga il regolamento (CEE) n.

1601/91 del Consiglio, come modificato dal regolamento (UE) 2021/2117 del Parlamento europeo e del Consiglio, del 2 dicembre 2021, deve essere interpretato nel senso che la nozione di «alcole», ai sensi di tale disposizione, che non può essere aggiunto a una bevanda designata come «cocktail aromatizzato di prodotti vitivinicoli», comprende una bevanda alcolica che, come la birra, non è un prodotto vitivinicolo, ai sensi dell'articolo 3, paragrafo 4, lettera a), di tale regolamento, quand'anche l'aggiunta di tale bevanda alcolica non porti ad un aumento del titolo alcolometrico di un tale cocktail rispetto a quello del prodotto o dei prodotti vitivinicoli cui si riferisce quest'ultima disposizione.

2) L'articolo 3, paragrafo 4, lettera c), del regolamento n. 251/2014, come modificato dal regolamento 2021/2117, deve essere interpretato nel senso che il divieto di aggiungere alcole a un «cocktail aromatizzato di prodotti vitivinicoli», previsto da tale disposizione, osta a che una bevanda alcolica che, come la birra, non è un prodotto vitivinicolo ai sensi di detta disposizione possa essere incorporata in un tale cocktail in quanto «prodotto alimentare sapido», ai sensi dell'allegato I, punto 1, lettera b), ii), di tale regolamento.

Corte giustizia Unione Europea, Sez. V, 21/03/2024, C-10/23, *Remia Com Impex SRL contro Autoritatea Națională Sanitară Veterinară și pentru Siguranța Alimentelor (ANSVSA), Direcția Sanitară Veterinară și pentru Siguranța Alimentelor Dolj*

Sicurezza alimentare – Norme in materia di igiene per gli alimenti di origine animale – Regolamento (CE) n. 853/2004 – Ambito di applicazione – Esclusioni – Fornitura di alimenti tra laboratori annessi agli esercizi di commercio al dettaglio che costituisce un'attività marginale, localizzata e ristretta – Nozione di "attività marginale, localizzata e ristretta" – Normativa nazionale che si discosta dalla definizione di tale nozione prevista da detto regolamento

L'articolo 1, paragrafo 5, lettera b), ii), del regolamento (CE) n. 853/2004 del Parlamento europeo e del Consiglio, del 29 aprile 2004, che stabilisce norme specifiche in materia di igiene per gli alimenti di origine animale, letto alla luce del considerando 13 di quest'ultimo, dev'essere interpretato nel senso che poiché tali disposizioni definiscono la nozione di «attività (...) localizzata» come l'approvvigionamento di esercizi situati nelle «immediate vicinanze», esso osta a una normativa nazionale che include in tale nozione forniture che vanno oltre un tale approvvigionamento, quali forniture a esercizi situati nell'intero territorio nazionale, e limita così la portata di tale regolamento.

Corte giustizia Unione Europea, Sez. VII, 22/02/2024, n. 745/22, *Micreos Food Safety BV contro Eniaios Foreas Elenchou Trofimon (EFET)*

Sicurezza alimentare – Norme specifiche in materia di igiene per gli alimenti di origine animale – Regolamento (CE) n. 853/2004 – Articolo 3, paragrafo 2 – Sostanza destinata ad eliminare la contaminazione superficiale dei prodotti di origine animale – Nozione – Contaminazione da batterio patogeno Listeria monocytogenes – Sostanza intesa a prevenire la contaminazione superficiale dei prodotti di origine animale e che si applica al di fuori dei macelli durante le ultime fasi del processo di produzione – Immissione in commercio – Approvazione preventiva da parte della Commissione europea

L'articolo 3, paragrafo 2, del regolamento (CE) n. 853/2004 del Parlamento europeo e del Consiglio, del 29 aprile 2004, che stabilisce norme specifiche in materia di igiene per gli alimenti di origine animale, come modificato dal regolamento (UE) 2019/1243 del Parlamento europeo e del Consiglio, del 20 giugno 2019, deve essere interpretato nel senso che richiede l'approvazione da parte della Commissione europea dell'uso di un prodotto, come il Listex™ P100, che mira a prevenire la presenza del batterio patogeno Listeria monocytogenes negli alimenti di origine animale pronti per il consumo.

Corte giustizia Unione Europea, Sez. VII, 29/02/2024, C-13/23, *cdVet Naturprodukte GmbH contro Niedersächsisches Landesamt für Verbraucherschutz und Lebensmittelsicherheit (LA-VES)*

Sicurezza alimentare – Additivi per l'alimentazione animale – Regolamento (CE) n. 1831/2003 – Procedura di autorizzazione – Divieto di commercializzazione in assenza di autorizzazione – Status dei prodotti esistenti – Validità ai sensi della Carta dei diritti fondamentali dell'Unione europea – Libertà d'impresa – Diritto di proprietà – Principio di proporzionalità – Regolamento di esecuzione (UE) 2021/758 – Ritiro dal mercato dell'estratto di pompelmo – Mangime contenente estratto di semi e di scorza di pompelmo

a) Solo gli additivi approvati secondo la procedura descritta nel Regolamento 1831/2003 possono essere immessi sul mercato, utilizzati e trasformati nell'alimentazione degli animali. Tale procedura di autorizzazione è prevista al capo II di detto regolamento, in cui figurano gli articoli da 3 a 15 di quest'ultimo. L'articolo 3, paragrafo 1, lettera a), del medesimo regolamento vieta l'immissione sul mercato, la trasformazione e l'uso degli additivi per mangimi che non hanno ottenuto un'autorizzazione. Dal combinato disposto dell'articolo 4, paragrafi 1 e 2, dell'articolo 8, paragrafi 1 e 3,

nonché dell'articolo 9, paragrafo 1, del regolamento n. 1831/2003 risulta che, in un primo momento, la domanda di autorizzazione è oggetto di un parere dell'EFSA, ai fini del quale tale autorità effettua una valutazione dei rischi al fine di determinare se l'additivo di cui trattasi soddisfi le condizioni di autorizzazione stabilite da tale regolamento. In un secondo momento, l'autorizzazione è concessa o rifiutata da un regolamento adottato dalla Commissione nell'ambito dell'esercizio delle sue competenze di esecuzione. Nell'elaborare il progetto di regolamento che concede o rifiuta l'autorizzazione, la Commissione tiene conto, in particolare, di tali condizioni di autorizzazione nonché di altri fattori legittimi connessi al settore considerato e, in particolare, dei benefici per la salute e il benessere degli animali e per il consumatore dei prodotti di origine animale. L'articolo 10 del regolamento n. 1831/2003 prevede che, in deroga all'articolo 3, gli additivi immessi sul mercato, in particolare, a norma della direttiva 70/524 possono continuare ad essere immessi sul mercato a condizione, in particolare, che una domanda di autorizzazione sia stata presentata entro sette anni dall'entrata in vigore di tale regolamento.

b) L'allegato I, capo I.A, parte 1, del regolamento di esecuzione (UE) 2021/758 della Commissione, del 7 maggio 2021, relativo allo status di determinati prodotti come additivi per mangimi che rientrano nel campo di applicazione del regolamento (CE) n. 1831/2003 del Parlamento europeo e del Consiglio e al ritiro dal mercato di determinati additivi per mangimi, deve essere interpretato nel senso che rientra nella nozione di «estratto di pompelmo», in forza di tale disposizione, un estratto prodotto a base di semi e scorze di pompelmo.

Corte cost., 26/03/2024, n. 49

Sugar tax - Tributi – In genere – Principio dell'eguaglianza tributaria – Possibile diversificazione tra contribuenti, supportata da adeguata giustificazione – Discrezionalità del legislatore, con il limite della non arbitrarietà

La giustificazione dell'introduzione della imposta sulle bevande analcoliche edulcorate discende dalla attitudine delle stesse, per la loro particolare composizione, a provocare diabete, obesità e altre patologie non trasmissibili: attitudine puntualmente attestata da studi scientifici riversati in raccomandazioni di organismi internazionali specificamente volti a suggerire l'imposizione fiscale sulle medesime bevande. Deve dunque essere dichiarata non fondata la questione di legittimità costituzionale dell'art. 1, commi da 661 a 676, della L. 27 dicembre 2019, n. 160.

Cass. pen., Sez. III, Sentenza, 28/03/2024, n. 15117

Delitti contro l'industria e il commercio - Frode nell'esercizio del commercio - Contaminazione di prosciutti dovuta all'utilizzo di insetticidi per la disinfestazione della sala di stagionatura - Configurabilità del delitto di frode in commercio - Esclusione - Configurabilità dell'illecito amministrativo di cui all'art. 6, comma 5, d.lgs. n. 193 del 2007 - Sussistenza

Integra l'illecito amministrativo di cui all'art. 6, comma 5, d.lgs. 6 novembre 2007, n. 193, e non il delitto di frode in commercio, la condotta di chi detiene per la vendita prosciutti conservati, durante la fase di stagionatura, in sale sottoposte a trattamenti di disinfestazione eseguiti con insetticidi nebulizzati, il cui utilizzo è vietato con riguardo agli alimenti.

Cass. pen., Sez. III, Sentenza, 15/02/2024, n. 10237

Prodotti alimentari (in genere) - Reati - In genere - Presenza di additivi chimici negli ingredienti utilizzati- Reato configurabile - Art. 5, comma 1, lett. g), legge n. 283 del 1962 - Art. 516 cod. pen. - Individuazione

Integra la contravvenzione di pericolo presunto di cui all'art. 5, comma 1, lett. g), legge 30 aprile 1962, n. 283, punibile a titolo di colpa, l'originario impiego o la colposa aggiunta di additivi chimici non autorizzati negli ingredienti utilizzati per la preparazione di prodotti alimentari, mentre dà luogo al delitto previsto dall'art. 516 cod. pen., punibile a titolo di dolo, l'aggiunta intenzionale della sostanza vietata.

Cass. pen., Sez. V, 16/01/2024, n. 13767

Reati alimentari – adulterazione del vino – commercializzazione del vino adulterato – rapporto fra fattispecie di illecito

In tema di reati alimentari, tra l'art. 516 c.p. e l'art. 33, comma 2 della L. 82/2006 (che prevede solo una sanzione amministrativa) non è ravvisabile alcun rapporto di specialità, trattandosi di due fattispecie differenti, che hanno in comune solo l'oggetto materiale del reato (il vino adulterato, quale sostanza alimentare non genuina), ma che divergono radicalmente nella descrizione della condotta: l'una afferente alla pregressa fase della adulterazione e, l'altra, a quella successiva della commercializzazione.

Cass. pen., Sez. III, 12/01/2024, n. 18369

Vendita di sostanze alimentari non genuine come genuine – fattispecie di reato – nozione di sostanza nociva

In tema di quantificazione della pena per il reato di cui all'art. 516 c.p., correttamente il giudice può determi-

narla ritenendo particolarmente insidiosa la condotta posta in essere dall'imputato, ove la stessa risulti legata alla somministrazione di sostanze nocive, nell'ambito di una fattispecie penale che fa riferimento, non alla nocività degli additivi, ma alla semplice non genuinità delle sostanze alimentari.

AMBIENTE

Corte giustizia Unione Europea, Sez. VII, 21/03/2024, C-671/22, *T GmbH contro Bezirkshauptmannschaft Spittal an der Drau*

Azione dell'Unione in materia di acque – Direttiva 2000/60/CE – Obiettivi ambientali relativi alle acque superficiali – Prevenzione contro il deterioramento dello stato di tutti i corpi idrici superficiali – Allegato V, punto 1.2.2 – Definizioni dello stato ecologico "elevato", "buono" e "sufficiente" dei laghi – Criteri di valutazione dell'elemento di qualità biologica "fauna ittica"

Il punto 1.2.2 dell'allegato V della direttiva 2000/60/CE del Parlamento europeo e del Consiglio, del 23 ottobre 2000, che istituisce un quadro per l'azione comunitaria in materia di acque, deve essere interpretato nel senso che da una parte, riguardo ai criteri di valutazione dell'elemento di qualità biologica «fauna ittica», si deve intendere per «alterazione antropica», ai sensi di tale punto, qualsiasi alterazione che ha origine in un'attività umana, inclusa qualsiasi variazione idonea a pregiudicare la composizione e l'abbondanza delle specie di pesci, e, dall'altra, tutte queste alterazioni sono rilevanti per la classificazione dello stato ecologico della «fauna ittica».

Cons. Stato, Sez. IV, 01/02/2024, n. 1044

Vincolo idrogeologico – oggetto - finalità

In urbanistica, la tutela derivante dal vincolo idrogeologico si estende anche agli interventi edificatori interessanti terreni non boschivi, purché compresi nell'area vincolata per cui la trasformazione dei terreni, cui fa riferimento l'art. 7 del R.D. n. 1126/1926, e i lavori di trasformazione, previsti dal successivo art. 21, del R.D. n. 1126/1926 consentono alla p.a. di adottare non già mere prescrizioni operative, bensì misure restrittive ed anche impeditive di ogni tipo di intervento che, per le sue caratteristiche e per i mezzi impiegati, incidano sul territorio in modo non dissimile dalle utilizzazioni per scopi agricoli.

Cass. pen., Sez. III, 23/11/2023, n. 813

Frantoi – acuqe di vegetazione – smaltimento - rifiuto

Premesso che i titolari dei frantoi oleari hanno la possibilità di smaltire le acque di vegetazione tramite l'utilizzazione agronomica secondo i dettami della legge n. 574/ 1996, attraverso uno scarico secondo il D.Lgs. n. 152/2006, ovvero trattandole come rifiuto sempre ai sensi del citato decreto, integra il reato di cui all'art. 137, comma 1, D.Lgs. n. 152/2006 lo sversamento senza autorizzazione delle acque di molitura in fognatura senza che si possa invocare la legge n. 221/2015, che ha modificato l'art. 101 D.Lgs. n. 152/2006 introducendo il comma 7-bis, che prevede che "Sono altresì assimilate alle acque reflue domestiche, ai fini dello scarico in pubblica fognatura, le acque reflue di vegetazione dei frantoi oleari", giacché tale assimilazione non interviene in modo automatico, ma presuppone il rispetto delle condizioni di cui alla norma citata.

ANIMALI

Cass. pen., Sez. III, 09/11/2023, n. 7529

Delitti contro il sentimento per gli animali - Delitto di cui all'art. 544-bis cod. pen. - Clausola di salvezza di cui all'art. 19-ter disp att. cod. pen. - Uccisione di animali "senza necessità" - Coincidenza con qualsiasi violazione della normativa sulla caccia - Esclusione – Ragioni

L'art. 19-ter esclude un'interpretazione dell'art. 544-bis cod. pen. nel senso che la locuzione "senza necessità" in esso contenuta possa coincidere semplicemente con una qualsiasi violazione della normativa sulla caccia già penalmente sanzionata dalla L. n. 157 del 1992. Diversamente opinando, vi sarebbe una inammissibile duplicazione di sanzioni per uno stesso fatto. La clausola di salvezza di cui all'art. 19-ter disp. coord. cod. pen. osta a che la locuzione "senza necessità", contenuta nell'art. 544-bis, comma primo, cod. pen., che regolamenta il delitto di maltrattamento di animali, sia intesa in senso coincidente con una qualsiasi violazione della normativa in tema di caccia, già penalmente sanzionata dalla legge 11 febbraio 1992, n. 157, posto che, diversamente opinando, vi sarebbe, con riguardo a uno stesso fatto, un'inammissibile duplicazione sanzionatoria.

CACCIA E PESCA

Cons. Stato, Sez. IV, 31/01/2024, n. 982

Divieto di caccia – parere ISPRA – piccola quantità cacciabile

Ai sensi dell'art. 19-bis della L. n. 157 del 1992, l'ISPRA è tenuto, oltre che ad emettere il parere sull'iniziativa delle regioni le quali intendano attivare una deroga

al divieto di cacciare talune specie di uccelli, anche a determinare, per tutto il territorio nazionale, la "piccola quantità" cacciabile degli uccelli per cui si vuole disporre la deroga; e se la regione non ha interesse ad impugnare il parere perché quest'ultimo, obbligatorio ma non vincolante, non impedisce alla regione stessa di discostarsi dal parere, con congrua motivazione, ha invece interesse a contestare la mancata determinazione della piccola quantità cacciabile, perché in tal caso il potere regionale di disporre ugualmente la deroga resta impropriamente paralizzato.

CONTRATTI AGRARI

Cass. civ., Sez. III, Ordinanza, 16/04/2024, n. 10309
Affitto di fondi rustici - Affitto a coltivatore diretto - Miglioramenti, addizioni e trasformazioni - In genere - Indennità per miglioramenti - Clausola di autorizzazione preventiva all'esecuzione di tutti i miglioramenti ritenuti opportuni - Nullità per indeterminatezza dell'oggetto - Sussistenza - Fondamento
In un contratto di affitto di fondo rustico, è nulla, per indeterminatezza dell'oggetto, la clausola che genericamente autorizza l'affittuario all'esecuzione di tutti i miglioramenti del fondo ritenuti opportuni, perché, in quanto volta a regolare l'oggetto dell'obbligazione contrattuale di pagamento dell'indennità per i miglioramenti (autorizzati), soggiace ai principi generali dell'art. 1346 c.c., secondo i quali l'oggetto dev'essere sempre determinato o determinabile (oltre che lecito e possibile).

Cass. civ., Sez. III, Ordinanza, 10/04/2024, n. 9725
Affitto di fondi rustici - In genere - Contratto di pascipascolo - Contratto di affitto di fondo pascolativo - Qualificazione - Elementi essenziali - Durata ultrannuale e uso esorbitante la mera raccolta di erba - Accordo tra le parti - Necessità - Pascolo - Vendita delle erbe - In genere
Ai fini della qualificazione di un contratto come di affitto agrario e non di vendita di erbe (cd. pascipascolo) è necessario che gli elementi essenziali del tipo contrattuale, ossia la durata ultrannuale e l'uso esorbitante la semplice raccolta dell'erba, siano espressione di attività negoziale e che, dunque, l'attività di coltivazione esorbitante rispetto a quella di mera raccolta delle erbe costituisca il frutto di uno specifico accordo tra le parti e non di una iniziativa unilaterale.

Cass. civ., Sez. III, Ordinanza, 09/04/2024, n. 9570
Diritto di prelazione e di riscatto - In genere - Concorso tra più titolari del diritto di prelazione e del conseguente diritto di riscatto agrario - Soluzione del conflitto ad opera del giudice - Insussistenza negli aspiranti dei titoli preferenziali ex art. 7 del d.lgs. n. 228 del 2001 - Criteri di scelta del contraente - Individuazione - C.d. libertà contrattuale - Esclusione - Maggiore o minore attitudine a concretare la finalità delle norme - Necessità - Fondamento
In caso di concorso tra più titolari del diritto di prelazione e del conseguente diritto di riscatto agrario, il giudice, se nessuno degli aspiranti gode dei titoli preferenziali riconosciuti dall'art. 7 del d.lgs. n. 228 del 2001, deve accordare prevalenza ad uno piuttosto che agli altri in base alla maggiore o minore attitudine a realizzare l'obiettivo per il quale la prelazione è stabilita, ossia l'ampliamento delle dimensioni territoriali dell'azienda diretto-coltivatrice che meglio realizzi le esigenze di ricomposizione fondiaria, di sviluppo aziendale e di costituzione di unità produttive efficienti sotto il profilo tecnico ed economico, prescindendo dalla priorità temporale dell'iniziativa dell'uno o dell'altro, e senza che possa trovare applicazione il criterio della libera scelta da parte del venditore, atteso che la norma citata non ha rivoluzionato i criteri già contenuti nell'art. 8 della l. n. 590 del 1965 e nell'art. 7 della l. n. 817 del 1971, ma ne ha introdotti altri, più moderni, lasciando immutati gli obiettivi del sistema della prelazione e del riscatto agrario.

Cass. civ., Sez. III, Ordinanza, 27/03/2024, n. 8342
Diritto di prelazione e di riscatto - In genere - Diritto di prelazione e riscatto agrario - Fondo parzialmente destinato al taglio degli alberi - Equiparazione della silvicoltura alla coltivazione - Fondamento
Il diritto di prelazione e riscatto agrario, di cui all'art. 8 della l. n. 590 del 1965, spetta anche in relazione al fondo, oggettivamente unitario, parzialmente destinato all'attività di raccolta di legname nella sua porzione boschiva, perché la silvicoltura costituisce una forma di coltivazione da intendersi come cura del bosco, che, se non trattato come bene intangibile, è destinato a produrre frutti e servizi di natura agricola.

Cass. civ., Sez. III, Ordinanza, 27/03/2024, n. 8338
Diritto di prelazione e di riscatto - Prelazione - Coltivatore diretto proprietario di fondi confinanti - Condizioni - Equiparabilità a quelle previste per l'affittuario, il mezzadro, il colono o il compartecipe – Sussistenza
In tema di prelazione agraria, al proprietario di un fondo agrario confinante con altro offerto in vendita compete il diritto di prelazione, ovvero il succedaneo diritto di riscatto, se ricorrono nei suoi confronti tutte le condizioni previste dall'art. 8 della l. n. 590 del 1965, cui l'art.

7 della l. n. 817 del 1971 integralmente rinvia; ne consegue che il diritto di prelazione del confinante si configura come un nuovo e distinto diritto subordinato ad altre condizioni, risultando invero soggetto, per il suo sorgere, alle stesse condizioni indispensabili perché lo stesso diritto sorga in capo all'affittuario, al mezzadro, al colono o al compartecipe insediato sul fondo in vendita.

Cass. civ., Sez. III, Ordinanza, 25/03/2024, n. 7995
Controversie - Procedimento - Competenza e giurisdizione - In genere - Controversie in materia di riscatto di fondo rustico - Competenza del giudice ordinario - Sospensione feriale dei termini - Fondamento - Proposizione di una domanda riconvenzionale - Conseguenze- Cumulo di cause - Declinatoria di competenza - Rimessione alla sezione agraria specializzata - Controversie - Procedimento- Competenza e giurisdizione - Sezioni specializzate - Termini processuali – Sospensione
Le controversie in tema di riscatto agrario, poiché affidate alla competenza del giudice ordinario e non alla competenza delle sezioni specializzate agrarie, sono soggette alla sospensione feriale dei termini, a meno che non sorga la necessità, per effetto di una domanda riconvenzionale, di accertare l'esistenza del rapporto agrario legittimante ed il cumulo di cause venga rimesso, per competenza, alla sezione specializzata.

Cass. civ., Sez. III, Ordinanza, 21/03/2024, n. 7525
Diritto di prelazione e di riscatto - Prelazione - Diritto di prelazione - Mancato esercizio - Vendita a soggetto diverso dal promissario acquirente - Nuova denuntiatio - Obbligo del venditore - Sussistenza - Atteggiamento tenuto dal prelazionario in precedenza – Irrilevanza
Il proprietario del fondo agricolo che, dopo avere stipulato un contratto preliminare di vendita ed in assenza d'un valido esercizio del diritto di prelazione, decida di venderlo a persona diversa dal promissario acquirente ed a prezzo maggiorato, ha l'onere di reiterare la denuntiatio al titolare del diritto di prelazione, a prescindere dall'atteggiamento da questi serbato in precedenza

Cass. civ., Sez. III, Ordinanza, 21/03/2024, n. 7525
Diritto di prelazione e di riscatto - Prelazione - Possibilità di subordinare il pagamento del prezzo a termini e condizioni - Esclusione - Accertamento di un controcredito del prelazionario nel giudizio di accertamento del valido esercizio della prelazione - Ammissibilità- Fondamento
Il valido esercizio del diritto di prelazione agraria non consente la subordinazione del pagamento del prezzo a termini e condizioni posti dal prelazionario, il quale, tuttavia, può chiedere, nel medesimo giudizio in cui ha domandato l'accertamento del diritto di prelazione, una pronuncia su un proprio credito nei confronti del venditore, non alterando tale domanda la parità di condizioni tra il prelazionario ed il terzo acquirente.

Cass. civ., Sez. II, 06/02/2024, n. 3313
Diritto di prelazione e di riscatto - In genere - Art. 8 l. n. 590 del 1965 - Norma di stretta interpretazione - Qualità di coltivatore diretto dell'avente diritto - Coltivazione del fondo - Necessità di valido titolo - Sussistenza - Concessione in comodato - Rilevanza - Esclusione
In tema di rapporti agrari, la disposizione di cui all'art. 8, comma 1, della l. n. 590 del 1965 - da considerare norma di stretta interpretazione in quanto apporta speciali limitazioni al diritto di proprietà - contempla un numero chiuso di situazioni soggettive protette e non può, pertanto, trovare applicazione oltre i casi ivi previsti. Ne deriva che il diritto di prelazione (e riscatto) agrario può essere esercitato solo da chi - coltivatore diretto - possa vantare, per effetto di un contratto concluso con il proprietario del fondo oggetto di trasferimento a titolo oneroso, la qualifica, alternativamente, di "affittuario", "colono", "mezzadro" o "compartecipante", con la conseguenza che esso non spetta a chi detenga il fondo, oggetto di compravendita, a titolo di comodato, non potendo quest'ultimo qualificarsi come contratto agrario.

IMPRESA

Cass. civ., Sez. lavoro, Ordinanza, 13/02/2024, n. 3973
Coltivatore diretto - Assicurazione invalidità, vecchiaia e superstiti – prova della qualità
Ai fini dell'applicabilità dell'assicurazione per l'invalidità, la vecchiaia ed i superstiti, la qualità di coltivatore diretto - rispetto alla quale manca nell'ordinamento una nozione generale applicabile ad ogni fine di legge - deve essere desunta dal combinato disposto degli artt. 2 della L. n. 1047 del 1957 e 2, 3 della L. n. 9 del 1963. Non è, pertanto, richiesto il carattere imprenditoriale dell'attività, con la destinazione, anche parziale, dei prodotti del fondo al mercato, essendo sufficiente che gli stessi siano destinati al sostentamento del coltivatore e della sua famiglia, né è prescritto che il coltivatore abbia personalmente prestato centoquattro giornate lavorative annue, riferendosi tale limite al fabbisogno del fondo e non all'attività del singolo.

Cass. civ., Sez. III, Ordinanza, 29/01/2024, n. 2726
Affitto a coltivatore diretto - Coltivatore diretto - Soggetti equiparati - Contratto di affitto agrario - Equiparazione tra coltivatore diretto e imprenditore agricolo professionale ex art. 7 l. 203 del 1982 - Applicabilità temporale
In tema di contratti di affitto agrario l'equiparazione ai coltivatori diretti degli imprenditori agricoli professionali iscritti nella previdenza agricola, stabilita dall'art. 7, comma 3, della l. n. 203 del 1982 ai fini dell'applicabilità delle disposizioni della stessa legge, rileva soltanto per i contratti stipulati a far data dal 1 gennaio 2018, data di entrata in vigore della l. n. 205 del 2017.

PROPRIETA'

Cass. civ., Sez. V, Ordinanza, 07/02/2024, n. 3474
Piccola proprietà contadina - Agevolazioni tributarie ici - Terreni edificabili destinati ad uso agricolo - Beneficio ex art. 2, comma 1, lett. b), del d.lgs. n. 504 del 1992 - Prova dei requisiti per il regime agevolativo - Fascicolo aziendale - Sufficienza - Condizioni - Tributi locali posteriori alla riforma tributaria del 1972
In tema di ICI, per considerare agricolo un terreno, pur suscettibile di utilizzazione edificatoria, ai sensi dell'art. 2, comma 1, lett. b), del d.lgs. n. 504 del 1992, il fascicolo aziendale, di cui all'art. 9 del d.P.R. n. 503 del 1999, contiene dati utilizzabili ma, al fine di provare nell'ambito di un giudizio contenzioso il possesso in capo al proprietario del requisito della diretta conduzione del fondo e, in generale, dei requisiti per beneficiare del regime agevolativo, occorre una verifica da parte del giudice di merito della sufficienza, adeguatezza, completezza e rilevanza delle informazioni ivi riportate, tenuto conto degli oneri probatori incombenti sul contribuente.

TRIBUTI, CONTRIBUTI E AGEVOLAZIONI
Cass. civ., Sez. V, Ordinanza, 08/03/2024, n. 6346
Agricoltura – agevolazioni – ICI – società di capitali - IAP
In materia di agevolazioni Ici per il settore agricolo, le misure di favore sono estendibili a società agricola di capitali, sempre che detta società possa essere considerata imprenditore agricolo professionale ovvero se, oltre ad avere da statuto come oggetto sociale esclusivo l'esercizio delle attività specifiche del settore agricolo, abbia almeno un amministratore che possieda i requisiti necessari per la qualifica di imprenditore agricolo professionale.

Cass. civ., Sez. V, Ordinanza, 07/02/2024, n. 3474
Piccola proprietà contadina - Agevolazioni tributarie ici - Terreni edificabili destinati ad uso agricolo - Beneficio ex art. 2, comma 1, lett. b), del d.lgs. n. 504 del 1992 - Prova dei requisiti per il regime agevolativo - Fascicolo aziendale - Sufficienza - Condizioni - Tributi locali posteriori alla riforma tributaria del 1972
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T.A.R. Lombardia Brescia, Sez. II, 29/02/2024, n. 164
Pagamenti – prelievo supplementare – rateizzazione - compensazione – campagne diverse - esclusione
L'AGEA non può procedere alla riscossione coattiva del prelievo supplementare se il produttore abbia presentato domanda di rateizzazione, tranne quando si sia verificata la decadenza dal beneficio per mancata sottoscrizione del contratto o per mancata effettuazione dei pagamenti alle scadenze stabilite. La compensazione sul prelievo supplementare deve quindi essere dedotta in giudizio mediante inequivoche attestazioni provenienti dagli organismi pagatori regionali, o essere accertata nei confronti degli stessi previa integrazione del contraddittorio, e deve riguardare le campagne oggetto di contestazione. Non è possibile la compensazione incrociata con campagne diverse, in quanto ciascuna campagna ha una storia giuridica a sé, che deve essere oggetto di uno specifico accertamento.

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