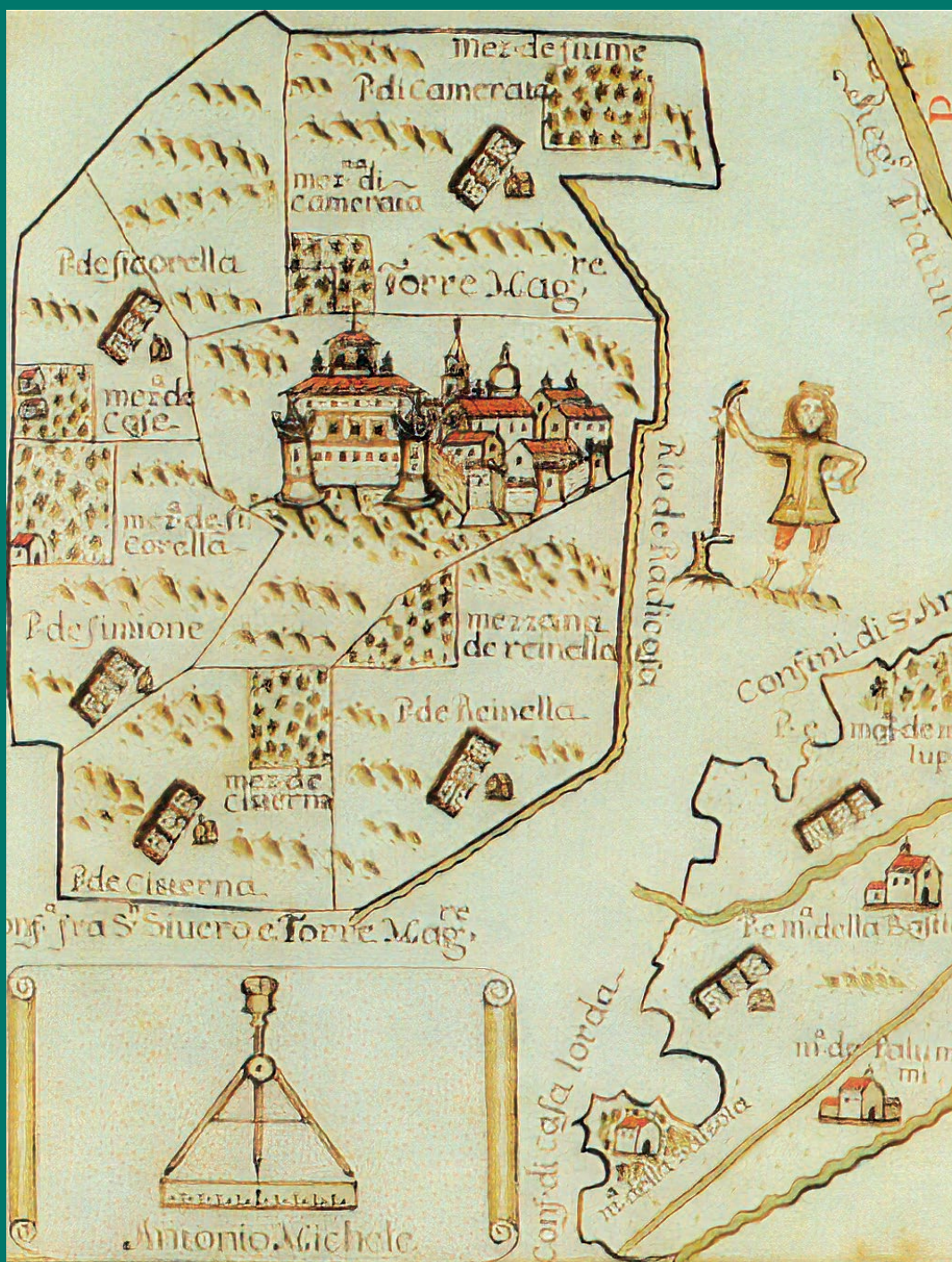




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Using a spatial econometric approach to identify the main determinants and spillover effects of residential property prices in La Spezia (Italy)

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Abstract. We employ a spatial econometric approach to investigate the factors influencing residential property prices in La Spezia province (Italy). Unlike traditional hedonic models, which often overlook spatial dependencies, our methodology explicitly accounts for spatial autocorrelation, thereby yielding more robust and accurate estimates. Diagnostic spatial tests reveal significant spatial dependence in both property prices and context variables. To address this, we adopt the Spatial Durbin Error Model (SDEM), using a first-order Queen contiguity weight matrix. This model not only enhances explanatory power but also improves predictive accuracy. By incorporating spatial effects, the SDEM enables the disentanglement of direct and spillover influences, offering a more comprehensive understanding of the determinants of property prices. The findings demonstrate the importance of spatially-aware models not only in the formulation of effective housing policies and urban development strategies but also in appraisal practices, where they improve the accuracy of real estate valuation.

Keywords: spatial autocorrelation, econometric spatial models, real estate market analysis.

JEL codes: R31, R32, O18, C53.

1. INTRODUCTION

Understanding the main determinants of residential property prices is essential for both policymakers and real estate appraisers, as property values play a pivotal role in shaping urban development strategies, infrastructure planning, and investment decisions (Marinković et al., 2024). The ability to accurately assess these determinants is critical for formulating policies that support sustainable urban growth, promote efficient land use, and ensure

housing affordability. Moreover, it is fundamental for producing more informative, precise and reliable property valuations (Appraisal Institute, 2020; European Construction Sector Observatory, 2019).

Traditional appraisal-based econometric models often operate under the assumption that housing markets function independently across different locations, treating each observation as spatially uncorrelated (Cunha and Lobão, 2021; De Ruggiero and Salvo, 2011; Salvo et al., 2021; Simonotti, 2006). However, this assumption overlooks the empirical reality that real estate markets frequently exhibit strong spatial dependencies (Case et al., 2004). The value (price) of a property is not solely determined by its intrinsic characteristics, but is also influenced by the attributes of surrounding properties and a variety of spatial factors, including neighborhood characteristics, accessibility to key amenities, and externalities generated by nearby land uses (Fingleton, 2006; Lo et al., 2022; Riccioli et al., 2021; Salvo et al., 2022; Zhang et al., 2021;). These influences give rise to spatial patterns in housing prices, where high-value properties tend to cluster in more desirable areas, while lower-value properties are typically concentrated in less attractive locations (Jin et al., 2024).

Moreover, spillover effects play a fundamental role in shaping real estate markets (Ganduri et al., 2023; Giuffrida et al., 2023; Kishor, 2022; Li et al., 2021). Property prices can be influenced not only by the characteristics of the asset itself but also by nearby transactions, as buyers and sellers often rely on recent sales in the vicinity as reference points in their valuation processes (Paraschiv and Chenavaz, 2011). In addition, urban renewal initiatives, changes in zoning regulations, or infrastructure investments in a specific area can generate significant ripple effects, influencing property prices in neighboring areas (Lee et al., 2022). If these spatial interactions are not adequately accounted for, conventional econometric models may yield biased or inefficient estimates, potentially leading to incorrect conclusions about the true determinants of housing prices (Anselin, 2022).

This study contributes to the literature on the application of the hedonic approach to real estate market by examining the direction and strength of the association between property prices and their potential determinants within a spatial econometric framework.

While spatial econometric models have been widely applied worldwide to detect real estate markets dynamics, much of the existing literature focuses on large metropolitan areas, where price trends are driven by high population density, extensive infrastructure, and diverse economic activities (Locurcio et al., 2020). Medium-sized cities, however, present distinct spatial and eco-

nomic characteristics that require tailored analytical approaches.

This study addresses this gap by applying spatial econometric techniques to detect the main determinants of properties prices in the province of La Spezia (Italy), a medium-sized urban area where real estate market dynamics remain underexplored. Given that the spatial test reveals significant spatial autocorrelation in the data, we specify and estimate alternative spatial model formulations in line with the Manski framework (Manski, 1993). The estimation results indicate that the Spatial Durbin Error Model (SDEM) provides the best fit, as it effectively captures spatial dependence in both the error terms and the exogenous interaction effects. The model is estimated using a first order Queen criterion to define neighborhood relationships. Within this framework, we identify the intrinsic and contextual variables that significantly affect residential property price in the study area. Further, the model allows for the estimation of both direct and spillover effects. The direct effect captures the impact of a change in a given explanatory variable on the dependent variable within the same spatial unit, whereas the spillover (or indirect) effect reflects how changes in that variable in one location influence property prices in neighboring areas (Elhorst, 2010).

The remainder of the paper is structured as follows: Section 2 reviews the relevant literature on the main determinants of property prices and the applications of spatial econometrics techniques to real estate markets. Section 3 outlines the methodology framework, including model specifications and the construction of spatial weight matrices. Section 4 presents the empirical results, while Section 5 offers a discussion of the findings, highlights their implications and concludes with key takeaways and suggestions for future research directions.

2. LITERATURE REVIEW

The factors influencing property prices are multifaceted and complex. Traditionally, they are primarily associated with demand-side and supply-side features, market characteristics, financial conditions, and socio-demographic dynamics (De Noni et al., 2019; Herath and Maier, 2010; Musa ad Yusoff, 2017; Poulhes, 2018). However, the literature also highlights the significant role of neighborhood characteristics in shaping property values. Both local amenities and disamenities have been shown to exert a substantial influence on housing prices (Aziz et al., 2023; Chen et al., 2023; Musa et al., 2015; Sani et al., 2023; Seo, 2020). Accessibility is generally found to be positively correlated with property prices,

while urban form and neighborhood attributes also play a significant role in shaping price dynamics over time (Can, 1990; Guan and Peiser, 2018; Mahan et al., 2000). Empirical studies have demonstrated that different neighborhood characteristics exert heterogeneous effects on average housing prices and can moderate the impact of individual property attributes on prices (Belk, 2018; Bolitzer and Netusil, 2000; Chang and Lin, 2012). Overall, the literature suggests that a comprehensive analysis of multiple neighborhood variables is essential for accurately estimating their impact on residential property values (Musa et al., 2015).

Recent advancements in Geographic Information Systems (GIS) have significantly expanded the range of contextual variables available that can be incorporated into hedonic pricing models for property valuation (Arcuri et al., 2020; Chau and Chin, 2003). GIS enables the incorporation of spatial data, including environmental amenities, location-based attributes, and distance measurements to various points of interest (Aladwan and Ahamad, 2019; Osland et al., 2022; Wang et al., 2017). The integration of GIS-derived data has been shown to enhance the predictive accuracy of hedonic models by facilitating the analysis of spatially explicit variables (Bernknopf et al., 2010). In the Italian context, researchers have applied these techniques to investigate real estate dynamics in key areas, including Cagliari (Zoppi et al., 2015), Venice (Rosato et al., 2017), Naples (De Toro et al., 2020), and Milan (Morena et al., 2021).

In addition, several studies have enhanced the predictive capabilities of hedonic pricing models by incorporating spatial econometric approaches to analyse property prices and their determinants. These approaches consistently reveal the presence of significant spatial effects, indicating that housing prices in a given area are influenced by price dynamics in neighbouring regions (Vergos and Hui Zhi, 2018). By employing such models, researchers have identified factors including income levels, commuting distance, housing stock characteristics, and school quality as significant determinants of property prices. Moreover, recent studies in the field underscore the importance of underutilized public and private properties in shaping local real estate markets. Disused or neglected properties often generate negative externalities, such as reduced surrounding property values and diminished neighborhood attractiveness, which in turn influence broader spatial economic dynamics (Sica et al., 2025; Tajani et al., 2023). In this context, another relevant factor in property valuation concerns the presence of contaminated areas, such as those with buildings containing asbestos. Recent studies highlight how proximity to such areas can generate negative effects on prop-

erty values due to health risk perceptions and potential remediation costs (Zihannudin et al., 2021). In a spatial analysis context, these effects can extend beyond immediate proximities, influencing the local real estate market through negative spillovers (Durst et al., 2024).

As it concerns the spatial mode specification, Spatial Autoregressive (SAR), Spatial Durbin (SDM), and Spatial Error (SEM) models, have been demonstrated to outperform traditional models in predicting housing prices (Stamou et al., 2017). A growing body of research in Italy has adopted spatial econometric techniques to analyze the dynamics of the real estate market. Olmo (1995) proposed a methodology for the spatial estimation of housing prices and locational rents, emphasizing the joint relevance of structural and locational characteristics. Rosato et al. (2008) examined the impact of cultural heritage on property prices in Italy, showing that proximity to historical landmarks significantly affects market equilibrium prices. Caliman et al. (2010) employed a spatial econometric framework to investigate price dynamics and spatial autocorrelation in the Italian housing market. Nobili and Zollino (2012) developed a structural model, highlighting the role of disposable income, demographic pressures, and credit conditions in determining housing prices. Barreca et al. (2018) explored housing vulnerability in Turin, identifying physical buildings features and socio-economic conditions as key determinants of property prices. Cipollini et al. (2020) utilized a Global Vector Autoregressive (GVAR) model to assess the spatio-temporal spillover effects of housing market shocks on prices and transaction volumes across Italian provinces. Bocci et al. (2019) investigated spatial interactions in property tax policies among municipalities, revealing that local tax decisions are influenced by neighbouring jurisdictions. Finally, Copiello (2020) analyzed spatial and serial dependence in residential property values in Northeastern Italy, finding that exogenous factors can mitigate spatial spillover effects.

3. DATA

The dataset comprises 138 residential property sale deeds from the province of La Spezia, located in Northwestern Italy, covering transactions that occurred between 2004 and 2021 (see Figure 1). The properties are classified according to the Italian cadastral system as follows: A/1 (luxury dwellings situated in prestigious areas, characterized by high-end construction features and fine finishes), representing 1% of the sample; A/2 (standard residential units intended for civilian use), accounting for 73%; and A/3 (economically accessible



Figure 1. Spatial distribution of sold residential properties.

housing), comprising the remaining 26%. Information on property prices and intrinsic attributes (as reported in Table 1) has been made available for analysis by the Italian Institute for Resources for Economic Development (IIRISE), a society operating in the field of properties valuation and managing a real estate database named “Comparabilia.it” that stores information on properties that have been sold, allowing for market trend analysis and accurate real estate valuations¹. Given that the sales occurred across different years, all property prices have been adjusted to May 2022 values using consumer price indices².

Additional contextual and territorial information was obtained through GIS elaboration of data provided

by the geoportal of the Liguria Region³ and by IGIS-MAP⁴. Table 1 reports descriptive statistics for variables used in the analysis.

4. ECONOMETRIC ANALYSIS

The econometric analysis followed three main steps (see Figure 2). The first step involved the selection of the spatial weight matrix, a fundamental component in spatial econometric models that represents the spatial relationships among geographic units. This matrix defines, *a priori*, the structure of spatial dependence by assigning weights to pairs of observations based on their geographical proximity or connectivity. The choice of the weight matrix is critical, as it determines which observations are considered “neighbors” and therefore potential-

¹ The Comparabilia database contains data derived from approximately 1,500,000 geolocated property sale deeds, which are integrated with cadastral information. These data are primarily utilized by professionals involved in appraisal activities, who access the information through a user-friendly, subscription-based platform (<https://comparabilia.it>).

² <https://rivaluta.istat.it/Rivaluta/Widget/calcolatoreWidget.jsp>.

³ <https://geoportal.regione.liguria.it>.

⁴ <https://map.igismap.com/gis-data>.

Table 1. Summary statistics of data.

Variable	Unit of measurement	Source	Mean (or percentage)	Standard deviation	Min	Max
Price of sale (May 2022)	€	(a)	220,987	157,866	194,648	247,326
Age of the property	Years	(a)	54.17	34.95	7.00	350.00
Renovated property	(1 if yes)	(a)	67.00%			
Cadastral class	(1 if A/3)	(a)	26.00%			
Property surface	m ²	(a)	96.60	43.71	24.30	299.00
Floor level	n.	(a)	1.94	1.59	0.00	7.00
Property type_2	(1 if bivans)	(a)	5.00%			
Property type_3	(1 if tree-rooms)	(a)	17.00%			
Property type_4	(1 if four-rooms)	(a)	29.00%			
Property type_5	(1 if six-rooms)	(a)	25.00%			
Property type_6	(1 if seven-rooms)	(a)	16.00%			
Property type_7	(1 if eight-rooms)	(a)	8.00%			
judicial sale	(1 if yes)	(a)	1.00%			
Energy category < B	(1 if yes)	(a)	33.00%			
Years_restructuring services	years	(a)	2021.78	0.41	2021.00	2022.00
Tavern	(1 if yes)	(a)	1.00%			
Garage	(1 if yes)	(a)	15.00%			
Uncovered parking space	(1 if yes)	(a)	6.00%			
Covered parking space	(1 if yes)	(a)	7.00%			
Hill_area	(1 if located in a hill area)	(b)	3.00%			
Distance from primary schools	m	(b)	1596.23	1528.13	65.50	8337.90
Distance from highway entrance	m	(b)	3011.47	2010.13	326.40	8729.40
Distance from historic places	m	(b)	630.63	421.97	5.40	2128.80
Distance from the railway station	m	(b)	2294.98	2663.87	101.90	17281.80
Distance from parking area	m	(b)	444.06	1,048.02	12.10	8,444.90
Number of parking places in a 1 km buffer	m	(b)	2.65	2.46	0.00	8.00
Distance from the cycleway	m	(b)	997.10	2232.92	1.40	15,547.40
Distance from landfills	m	(b)	10,084.88	5,207.52	1,947.90	25,287.30
Number of buildings with asbestos within a 1 km buffer	n.	(b)	0.09	0.34	0.00	2.00
Number of leisure associations within a 1 km buffer	n.	(b)	0.43	0.73	0.00	2.00
Number of sport clubs within a 1 km buffer	n.	(b)	0.62	0.65	0.00	2.00
Number of reception services within a 1 km buffer	n.	(b)	17.32	15.63	0.00	48.00
Number of food services within a 1 km buffer	n.	(b)	0.00	0.00	0.00	0.00
CORINE10*	1 if yes	(b)	41.00%			
Seismic zone_2	(1 if yes)	(b)	18.12%			
Seismic zone_3	(1 if yes)	(b)	17.39%			
Seismic zone_4	(1 if yes)	(b)		50.00%		

Note: (a) IIRISE-Comparabilità; (b) our GIS elaborations. *The property falls in the CORINE Land Cover class n. 10 (discontinuous urban fabric).

ly exert mutual influence. Given the limited geographical scope of the analysis and the objective of capturing local interactions, we adopted a first-order Queen contiguity matrix (Kopczewska, 2021). We verified that, compared to an Inverse Euclidean Distance Matrix, the contiguity-based matrix captures a higher level of spatial variability, as indicated by the squared value of Moran's I statistic (Kopczewska, 2021). Moran's I, along with associated

Z-values and p-values, was estimated using a computational approach based on 10,000 random permutations.

In the second step, we assessed the presence of spatial autocorrelation in both the dependent variable (property prices) and potential explanatory variables. Moran's I statistic, Z-values, and p-values were computed using a Monte Carlo simulation approach based on 10,000 permutations. The detection of significant spatial

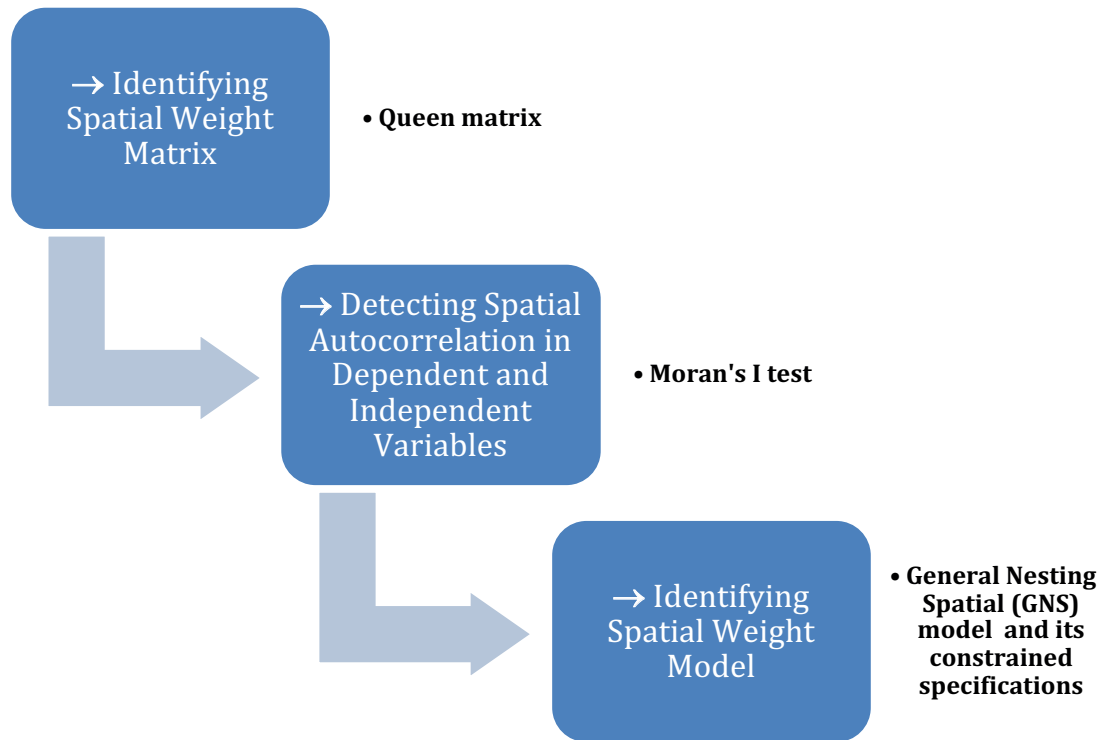


Figure 2. Steps of the econometric analysis.

dependence provided justification for the use of spatial econometric modelling. The selection of independent variables was guided by previous literature, particularly Algieri (2013).

In the final step, we followed the “general to specific” modelling strategy recommended by Elhorst (2010) to identify the most appropriate spatial model specification. This approach begins with the estimation of the General Nesting Spatial (GNS) model, originally proposed by Manski (1993). The GNS model incorporates three fundamental spatial lags: the spatial lag of the dependent variable (ρ), the spatial lag of independent variables (θ) and the spatial lag of the error term (λ). This comprehensive formulation allows for maximum flexibility in capturing various forms of spatial dependence. The general specification of the GNS model is as follows:

$$\ln(y) = \rho W_y Y + \alpha_{i_N} + X\beta + W_x X\theta + u \quad (1)$$

$$u = \lambda W_u u + \varepsilon \quad (2)$$

where:

- y is an $N \times 1$ vector consisting of one observation on the dependent variable for every unit in the sample ($i = 1, \dots, 138$);

- $\rho W_y y$ represents the endogenous interaction effect where W_y is an $N \times N$ non-negative spatial weight matrix that defines the arrangement of the observational units in the sample, and ρ that is the spatial lag parameter capturing the strength of the spatial dependence in the dependent variable;
- i_N is an $N \times 1$ vector of ones associated with the constant term parameter α ;
- X denotes an $N \times K$ matrix of exogenous explanatory variables, with the associated parameters β contained in a $K \times 1$ vector;
- $W_x X\theta$ represents the exogenous interaction effects, depending on W_x and on θ , that is the spatial Durbin parameter;
- $\lambda W_u u$ represents the interaction effect among error terms, depending on W_u and on λ , that is the spatial error parameter;
- ε is the idiosyncratic error term.

As shown in Equation (1), a log-linear functional form was assumed to allow marginal effects to vary with the levels of the explanatory variables. This specification enables the interpretation of coefficients as elasticities, thereby capturing the non-linear relationship between property prices and their determinants.

Table 2. Estimated spatial econometric models.

	Spatial Lag (ρ)	Durbin Component (θ)	Spatial Error (λ)
General Nesting Spatial (GNS) or Manski model	$\neq 0$	$\neq 0$	$\neq 0$
Spatial Autoregressive Combined (SAC) or Kelejian-Prucha model	$\neq 0$	$= 0$	$\neq 0$
Spatial Durbin Model (SDM)	$\neq 0$	$\neq 0$	$= 0$
Spatial Durbin Error Model (SDEM)	$= 0$	$\neq 0$	$\neq 0$
Spatial Auto-Regressive (SAR) or spatial lag model	$\neq 0$	$= 0$	$= 0$
Spatial Lag of X (SLX) model	$= 0$	$\neq 0$	$= 0$
Spatial Error Model (SEM)	$= 0$	$= 0$	$\neq 0$
Ordinary Least Squares (OLS) model	$= 0$	$= 0$	$= 0$

Source: adapted from Elhorst (2010).

The GNS model is a generalized model. Imposing restrictions on the value of spatial terms, it is possible to estimate other models that assume two or one spatial components. Generally, in the spatial econometric analysis, a satisfactory target is a model with two spatial factors, given that GNS often suffers from overspecification problems (Elhorst, 2014). Table 2 illustrates how reduced forms can be derived from the GNS by constraining the value of specific spatial term(s) to zero. These restricted models are the Spatial Autoregressive Combined (SAC) model, the Spatial Durbin Model (SDM), the Spatial Durbin Error Model (SDEM), the Spatial Autoregressive (SAR) model, the Spatial Lag of X (SLX) model, and the Spatial Error Model (SEM).

As suggested in literature (LeSage and Pace, 2014), models that include more than one spatial lag, must have the same spatial matrix for the three different spatial processes. That means that $W_y = W_x = W_u = W$, where W represents the best matrix specification selected as previously illustrated.

The spatial models were estimated using the Generalized Spatial Two-Stage Least-Squares (GS2LS) estimator, which provides consistent parameter estimates under both homoskedastic and heteroskedastic error structures (Drukker et al., 2013).

5. RESULTS

The analysis confirms that the adoption of the Queen contiguity matrix is appropriate for capturing spatial variability in property prices. Specifically, this matrix accounts for 9.08% of the variability in the dependent variable, compared to only 0.46% explained by the inverse Euclidean distance matrix. Using the Queen matrix, several contextual variables exhibit signif-

Table 3. Moran's I tests.

	Moran's I	z-value
Distance from primary schools	0.5884	12.1145 ***
Distance from the highway entrance	0.8172	17.0035 ***
Distance from historic places	0.5655	12.2424 ****
Distance from the railway station	0.6936	14.7962 ***
N. of leisure associations within a 1 km buffer	0.8587	17.4973 ***
N. of reception services within a 1 km buffer	0.8472	17.7447 ***
Distance from parking area	0.6272	14.6769 ***
N. of parking places in a 1 km buffer	0.7107	14.5517 ***
Distance from the cycleway	0.6781	15.2375 ***
N. of buildings with asbestos within a 1 km buffer	0.607	13.6188 ***
Seismic zone_2	0.4243	8.8786 ***
Seismic zone_3	0.4967	10.0675 ***
Seismic zone_4	0.7538	15.6493 ***

icant spatial autocorrelation. Table 3 presents the results of Moran's I tests applied to these contextual variables, which, based on the relevant literature, are considered potential determinants of property sale prices.

The findings indicate that the Spatial Durbin Error Model (SDEM) provides the best fit to the data, as it effectively accounts for spatial dependence in the error terms as well as exogenous interaction effects. Model comparison based on the Akaike Information Criterion (AIC) and the Bayesian Information Criterion (BIC) further supports the superiority of the SDEM specification. Table 4 reports the AIC and BIC values for all estimated models, clearly showing that the SDEM yields the most favorable performance metrics.

Table 5 reports the coefficient estimates of the SDEM specification, as well as estimates of its direct and indi-

Table 4. Estimates of AIC and BIC criteria*.

Model	ll(model)	df	AIC	BIC
Maski	4.97001	55	100.0600	261.0589
SAC	-24.83119	42	133.6624	256.6070
SDM	-6.138362	54	120.2767	278.3484
SDEM	4.721653	54	98.5567	256.6284
SLX	-6.697225	52	117.3945	269.6116
SEM	-25.69836	41	133.3967	253.4141
SAR	-25.06558	40	130.1312	247.2213
OLS	-25.76609	37	125.5322	233.8406

* AIC and BIC Criteria were estimated using the Maximum Log-Likelihood estimator.

rect effects. The estimates are consistent with the findings of previous aspatial studies, reinforcing the validity of the identified relationships between property prices and their determinants (Andreson and West, 2006; Ruggeri et al., 2023; Trojanek et al., 2018; Wong et al., 2011). Typical intrinsic characteristics – such as the age and size of the property, floor level, energy efficiency classification, and the presence of additional or ancillary spaces – emerge as key determinants of property prices. Furthermore, market segmentation based on property type and cadastral classification, as well as the conditions under which the transaction occurred (e.g., judicial sale), also significantly influence pricing dynamics (Simonotti, 2006).

Particularly noteworthy are the results related to contextual variables, as well as the sign and magnitude

of the estimated direct and spillover effects – made possible when the spatial parameter associated with a given contextual variable is statistically significant. The effects of these variables are consistent with theoretical expectations and align with findings from previous studies in the literature (Crompton, 2001; Hidano et al., 2015; Rosiers et al., 2001; Seo et al., 2014).

The spillover effect reinforces the direct effect only in the case of the variable “distance from the cycleway” which exhibits a negative total effect on property prices. In contrast, the remaining contextual variables generally exhibit spillover effects that are opposite in sign to their direct effects. For instance, variables such as the distance from primary schools, the number of leisure associations within a 1 km buffer, the distance from parking areas, and inclusion in seismic zone 2 (compared to other zones) display negative direct effects on property prices. However, these effects are partially offset by positive spillover effects from neighbouring areas. Conversely, the distance from the highway entrance shows a positive direct effect but is accompanied by a negative spillover effect. Moreover, as illustrated in Figure 3, for variables exhibiting a statistically significant Durbin component, the total effect is predominantly driven by the indirect component. These findings highlight the critical importance of accounting for both the direction and magnitude of spillover effects in order to fully understand the spatial dynamics governing property prices and their determinants.

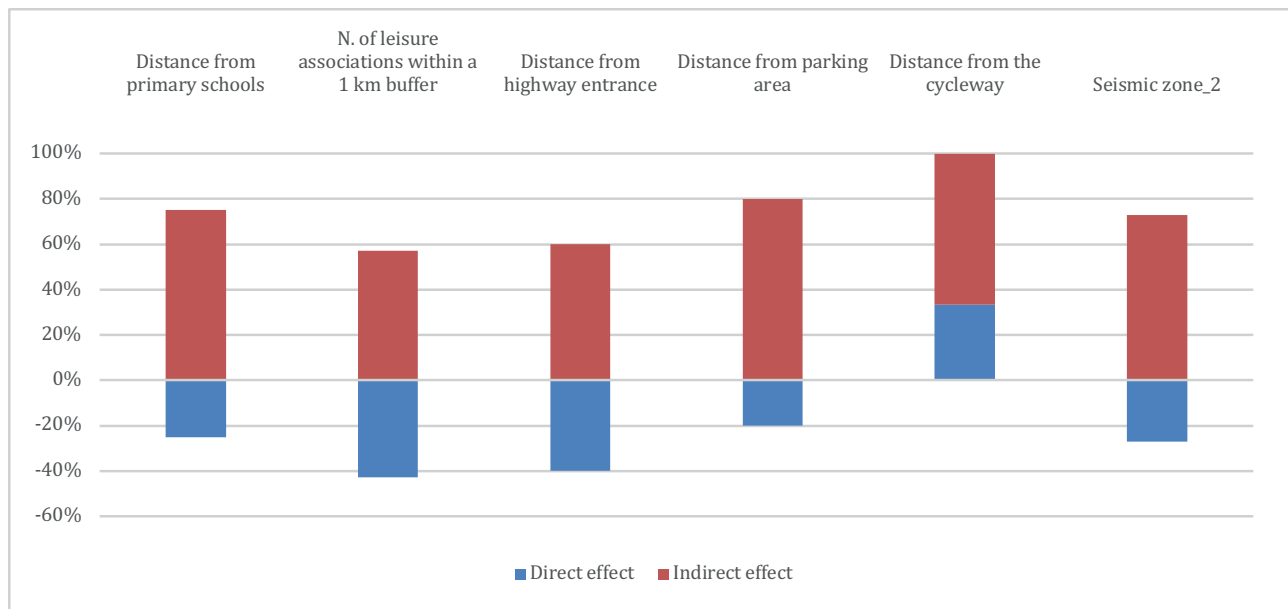
**Figure 3.** Total, direct and indirect effects.

Table 5. Estimates of the Spatial Durbin Error Model (SDEM), and direct and indirect effects.

	Coefficient estimates			Direct effect		Indirect effect		
	β	Std. Err.	θ	Std. Err.	dy/dx	Std. err	dy/dx	Std. Err.
Age of the property	-0.0022***	0.0006			-0.0022***	0.0006		
Renovated property	0.1451**	0.0530			0.1451**	0.0530		
Cadastral class	-0.3616***	0.0527			-0.3616***	0.0527		
Property surface	0.0073***	0.0015			0.0073***	0.0015		
Floor level	0.0934***	0.0183			0.0934***	0.0183		
Property type_2	0.7009**	0.2275			0.7009**	0.2275		
Property type_3	0.9927***	0.2045			0.9927***	0.2045		
Property type_4	1.0134***	0.2210			1.0134***	0.2210		
Property type_5	1.0480***	0.2336			1.0480***	0.2336		
Property type_6	1.1003***	0.2768			1.1003***	0.2768		
Property type_7	1.0019***	0.2995			1.0019***	0.2995		
Judicial sale	-0.6302**	0.2169			-0.6302**	0.2169		
Energy category	-0.1832**	0.0693			-0.1832**	0.0693		
Tavern	0.3747**	0.1302			0.3747**	0.1302		
Garage	0.1577*	0.0766			0.1577*	0.0766		
Uncovered parking space	0.2224(a)	0.1151			0.2224(a)	0.1151		
Covered parking space	0.3215**	0.1213			0.3215**	0.1213		
Hill_area	0.8116*	0.3491			0.8116*	0.3491		
Distance from historic places	-0.0004***	0.0001			-0.0004***	0.0001		
N. of reception services within a 1 km buffer	-0.0084**	0.0031			-0.0084**	0.0031		
N. of parking places in a 1 km buffer	0.0453**	0.0173			0.0453**	0.0173		
N. of buildings with asbestos within a 1 km buffer	-0.1895**	0.0615			-0.1895**	0.0615		
Distance from primary schools	-0.0001***	0.0000	0.0000***	0.0000	-0.0001***	0.0000	0.0003***	0.0000
N. of leisure associations within a 1 km buffer	-0.3071***	0.0804	0.0651***	0.0173	-0.3071***	0.0804	0.4094***	0.1086
Distance from highway entrance	0.0002***	0.0000	0.0000***	0.0000	0.0002***	0.0000	-0.0003***	0.0000
Distance from the parking area	-0.0002***	0.0000	0.0001***	0.0000	-0.0002***	0.0000	0.0008***	0.0001
Distance from the cycleway	-0.0001***	0.0000	0.0000**	0.0000	-0.0001***	0.0000	-0.0002**	0.0001
Seismic zone_2	-0.2305**	0.0810	0.0983***	0.0204	-0.2305**	0.0810	0.6180***	0.1285
α	10.5861***	0.3348						
λ	-0.0958**	0.0355						

Note: p<0.10, **p<0.05, *** p<0.001.

6. DISCUSSION AND CONCLUDING REMARKS

The identification of property price determinants empowers stakeholders to make informed decisions, adapt to evolving real estate market conditions, and design effective management strategies that address the complex interplay of environmental, technological, social, and economic challenges affecting urban and settlement systems. Appraisers can also benefit from this information by producing valuation judgments that more accurately reflect the actual functioning of the real

estate market, align with the expectations of buyers and sellers, and consider the spatial context in which the transaction may occur. By employing spatial econometric models and tools, researchers and practitioners can more effectively investigate which intrinsic and extrinsic factors significantly influence residential property prices. These models allow for the estimation of both the direction and magnitude of key relationships, while also accounting for spillover effects associated with spatially relevant variables. Spatial econometric models offer a nuanced understanding of the factors influenc-

ing property values, capturing not only the direct effects of explanatory variables but also the spatial interactions among neighbouring units. This methodological approach is consistent with a growing body of literature that underscores the role of sustainability measures – such as energy efficiency and decarbonization – in enhancing property values. Additionally, recent studies highlight the importance of specific property uses in promoting urban regeneration and generating positive externalities that extend beyond individual property boundaries. In the context of real estate market analysis and property appraisal, spatial econometric tools demonstrate the critical importance of accounting for spatial autocorrelation in the data. These models enhance the accuracy, reliability, and policy relevance of economic analyses by reducing the risk of coefficient bias – whether through underestimation or overestimation – and by improving the predictive validity of market value estimates. Ultimately, spatial econometric methods provide valuable support in explaining how and why property prices vary across space, and in identifying the underlying processes driving these spatial patterns. This paper presents the results of a spatial econometric hedonic analysis aimed at identifying the factors influencing residential property prices in La Spezia, Italy. The findings indicate that the Spatial Durbin Error Model (SDEM) provides the best-fitting specification, supporting the hypothesis of significant spatial dependence both in the error terms and in the interaction effects of exogenous variables. The results of this study emphasize the critical need for urban planners and real estate professionals to account for both direct and spillover effects when evaluating property prices. Intrinsic characteristics like the asset's age, size, and energy efficiency categories are key determinants and should be included as core variables in valuation models. Additionally, incorporating context variables (e.g., proximity to schools, highways, or cycleways) with spatial parameters allows for more accurate estimations that reflect spatial dependencies and interactions, aspects that cannot be ignored in real estate valuations. The significant spillover effects observed for certain variables – such as distance from the cycleway – suggest that investments in urban infrastructure can generate broader impacts beyond the immediate vicinity, influencing property values in surrounding areas. Urban planners can leverage this insight to prioritize infrastructure projects that are likely to yield positive spatial externalities. Conversely, the presence of negative spillover effects associated with factors such as distance from parking areas or location within seismic zones underscores the importance of implementing mitigation strategies, including improved accessibility and enhanced

safety measures. Positive effects linked to proximity to leisure associations and cycleways further highlight the value of fostering community-oriented, sustainable urban environments. Such amenities not only enhance the attractiveness of neighbourhoods but also contribute to increased property values. In contrast, areas adversely affected by proximity to undesirable features – such as seismic risk zones – may benefit from compensatory policy measures, including development incentives or robust disaster resilience planning, to offset negative market perceptions. The findings also emphasize the importance of market segmentation – particularly with respect to property type and cadastral classification – in shaping price dynamics. This information can support policymakers and real estate developers in designing targeted interventions that address the specific characteristics and needs of distinct market subsegments.

The observed influence of judicial sales on property prices underscores the critical importance of accounting for legal and procedural factors in real estate transactions. These considerations should be consistent with the market value definition established by the European Union in Regulation (EU) No 575/2013. Accordingly, this analysis aligns with findings from similar studies and emphasizes that failure to adhere to valuation standards – particularly in the selection of comparable properties – can result in significant distortions in price estimations. To operationalize these findings, it is essential that local governments and analysts have access to high-quality spatial data. Such data should encompass both intrinsic property characteristics and contextual variables with sufficient granularity to enable the accurate estimation of spatial interactions. Geographic Information Systems (GIS) can support this effort by facilitating the visualization and analysis of spatial relationships, thereby helping stakeholders to identify priority areas for targeted interventions. Incorporating both direct and spillover effects into urban planning and real estate valuation processes can contribute to the development of more sustainable, resilient, and equitable urban environments.

The study is not without limitations. Its focus on residential properties within the province of La Spezia may limit the generalizability of the findings to other property types or different urban contexts. Additionally, the analysis does not account for broader macroeconomic influences or regional policy interventions that may affect real estate dynamics. Nevertheless, despite these limitations, the study provides a robust foundation for analysing local housing markets and offers valuable insights to inform future research and policy development. Future research could build on this analysis by integrating additional explanatory variables and incorporating more recent

and comprehensive datasets. Expanding the geographical scope to include other medium-sized cities or different property types – such as commercial and industrial real estate – would facilitate a broader understanding of spatial dynamics across diverse urban contexts. Moreover, extending the temporal dimension of the dataset or incorporating more frequent updates would enable the examination of long-term trends, the impact of economic cycles, and the effects of external shocks on property markets. Further contributions could include an investigation into the spatial effects of urban regeneration initiatives and the repurposing of underutilized or vacant properties, which remain underexplored in the literature. Integrating social, demographic, and environmental indicators would also provide a more comprehensive understanding of the multifaceted drivers of property values. Finally, future studies could benefit from employing advanced spatial econometric techniques capable of capturing more complex relationships and interactions within the data.

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Tourism investment and poverty in Algeria's economy: does the Autoregressive Distributed Lag model provide new evidence?

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Abstract. Tourism is an effective method for attaining sustainable growth, reducing unemployment, and alleviating poverty because of its significance and influence on other economic activities. Therefore, the current investigation investigates the impact of tourism investment on poverty in the Algerian economy from 1995 to 2020. To study how tourism investment affects poverty reduction in both the short and long term, we use the Autoregressive Distributed Lag (ARDL) model. This model helps to handle issues like non-stationarity, connections between different areas, and correcting errors in the data. This paper contributes by providing empirical evidence of the impact of tourism investment on poverty reduction in Algeria and provides policy recommendations for sustainable growth. Policy implications can prompt policymakers to leverage tourism for poverty alleviation by promoting sustainable investment, improving infrastructure, and supporting employment. The study recognizes the prospects of tourism as a long-lasting economic driver of poverty alleviation. This research makes a significant contribution by presenting empirical evidence on how tourism contributes to poverty reduction in Algeria. We offer policymakers lessons to formulate effective policies that can maximize the economic and social impact of tourism.

Keywords: tourism investment, poverty, Algeria economy, individual family consumption, pro-poor tourism, ARDL model.

JEL codes: L83, I32, O55, D12, O18, C32.

1. INTRODUCTION

The scope and depth of poverty, as well as its disproportionately high prevalence in the least developed countries, render it one of the most significant challenges that the entire world is currently confronted with (Ruja et al., 2024). The initial objective of the 2030 Sustainable Development Agenda is to eradicate destitution. "Algeria believes that the strategy for poverty reduction should be considered not only in terms of improving people's basic monetary

income but also in its non-income dimensions” (United Nations, 2019).

Tourism, like any other productive activity, is a potent instrument that can enhance the quality of life for impoverished individuals and encourage sustainable development in local communities (Agarwal et al., 2024). Increasing the income of individuals and families is facilitated by the creation of a variety of employment opportunities in a variety of sectors, including transportation, handicrafts, hospitality, and local services, by tourism (Zhao et al., 2023). However, to achieve this goal, we need to understand how much the poor can access and benefit from tourism and how to help them take part in the industry more. The World Tourism Organization (UNWTO) is committed to this objective, as it is of the opinion that the potential of tourism can be more effectively leveraged to directly resolve poverty-related issues. The organization creates strategies and programs to empower the most vulnerable groups, including women, youth, and rural populations, by allowing them to participate in tourism activities and receive a fair portion of its revenues. It also encourages sustainable tourism, which guarantees the continuity of benefits for future generations by preserving the cultural and environmental heritage of tourist areas. UNWTO endeavors to create an enduring positive impact on impoverished local communities by emphasizing responsible and inclusive tourism. The organization’s objective is to transform tourism into a viable instrument for addressing poverty and promoting sustainable development in accordance with the 2030 Agenda (United Nations, 2015).

This research aims to investigate the relationship between poverty, as evidenced by household spending in Algeria, and tourism investment. Investment in the tourism sector is regarded as one of the most critical factors that can contribute to the improvement of economic conditions by generating employment opportunities, upgrading infrastructure, and increasing local income (UNWTO, 2011). Many people think that tourism development can greatly improve people’s lives, especially in developing countries that want to broaden their income sources instead of relying on just one area (Ashley and Mitchell, 2009). The primary objective of the investigation is to determine the nature of the correlation between household consumption and tourism investment in Algeria. Is the relationship between investing in tourism and increased household consumption, which in turn improves living standards, limited or ineffectual in the context of the Algerian economy? The research aims to understand these trends by comparing tourism investment data with household spending in Algeria (World Bank, 2020).

This research is significant in that it aims to elucidate the extent to which tourism can fuel economic and social development. Tourism investment is not limited to the construction of hotels and tourist facilities; it also includes the provision of local services that can stimulate the local economy by promoting minor industries, traditional crafts, and a variety of services (Sinclair, 1998). If the study shows that higher tourism investment leads to increased household spending, it could support the idea that focusing on tourism development could help reduce poverty and improve living standards in Algeria. The goal of this research is to provide science-based advice that will help create effective tourism strategies. This will improve the economy and living conditions for Algerian families while supporting the country’s efforts for sustainable development.

This research makes substantial contributions to understanding the correlation between poverty alleviation and tourism investment in Algeria. The research offers new information about how poverty and tourism are connected by using the Autoregressive Distributed Lag (ARDL) model. This model is well known for its ability to look at both short-term and long-term relationships between different factors. This method enables researchers to investigate the influence of tourism investment on poverty, as indicated by household consumption levels, across a variety of time periods. The research thereby offers novel perspectives on the potential of tourism to alleviate poverty in Algeria. Secondly, the research emphasizes the significance of tourism as a sustainable development tool. The results indicate that tourism investment can have a beneficial effect on the local economy by enhancing the quality of life and decreasing poverty rates. Investment in the tourism sector creates new employment opportunities, improves infrastructure, and stimulates tourism-related sectors such as transportation, trade, and handicrafts. This beneficial effect bolsters national endeavors to accomplish sustainable development objectives, with a particular emphasis on the initial objective of eliminating poverty. Thirdly, the model’s scientific recommendations inform the study’s concluding policy guidance. This guidance is intended to assist in the development of informed economic policies that are designed to encourage tourism investment as a means of reducing poverty. These suggestions can help policymakers find the key areas of tourism that have the most impact and use resources effectively, which will boost tourism’s role in economic and social growth. This research contributes to the body of knowledge regarding tourism economics in Algeria and offers a practical framework for policymakers to utilize tourism as a tool to enhance living standards and combat poverty in the nation.

The paper is divided into five primary sections: an introduction, a literature review, the study methodology, the estimation and results, and a conclusion that addresses the implications and limitations.

2. LITERATURE REVIEW

This literature review investigates the relationship between poverty alleviation and tourism investment, emphasizing a variety of studies that illustrate the potential of increased tourism to enhance living standards, stimulate local economies, and foster job creation. It examines the opportunities and obstacles that are linked to the development of tourism, underscoring the necessity of sustainable practices to guarantee long-term benefits for marginalized communities.

This review of the literature critically evaluates the correlation between poverty alleviation and tourism investment, emphasizing recent empirical studies from a variety of contexts, such as Indonesia, China, Latin America, Honduras, and specific regions within China. Pham and Nugroho (2022) examine the detrimental consequences of COVID-19 on tourism in Indonesia, with a particular emphasis on Bali, where the pandemic has significantly reversed over a decade of progress in poverty reduction. The study shows that the drop in tourism affects not just tourist areas, but also regions that don't rely on tourism because of trade between these areas. This is important for policymakers to consider.

Zhao and Xia (2020) offer empirical evidence in China that tourism, in conjunction with institutional variables, has a substantial impact on both absolute and relative poverty levels. Their research uses the Foster-Greer-Thorbecke (FGT) poverty measures to show that the effects are complicated and differ in size and importance over different time periods.

Winter and Kim (2021) use the capability approach to explore the relationship between tourism and poverty. They highlight that the people in their study value both the money and the other benefits that tourism brings. Their results indicate that these opportunities contribute to a variety of well-being factors, indicating that tourism can be a critical factor in the improvement of individual capabilities and, by extension, in the reduction in poverty.

Dossou et al. (2023) examine the relationship between poverty reduction, governance quality, and tourism in Latin America. Although governance quality promotes poverty alleviation, tourism development can exacerbate poverty under specific circumstances, according to their findings. It is intriguing that the authors disclose the complementary effects of governance and tour-

ism on poverty alleviation, and they provide policy recommendations to improve these connections.

Ridderstaat et al. (2022) suggest a framework for comprehending the relationship between poverty and tourism development, with a particular emphasis on Honduras. The results of their study suggest that the relationship between tourism and poverty is primarily direct and contextual, indicating that the role of tourism in poverty alleviation is influenced by specific market conditions and local contexts.

Li et al. (2022) focus on ethnic tourism in China. They show that areas with many ethnic minorities can see a big boost in their economies through tourism, especially when looking at how much it contributes to their overall economy. Their results suggest that the relationship changes and is not straightforward. The positive effects of tourism decrease when a place relies on it more than 34%. This underscores the significance of context in comprehending the influence of tourism on poverty alleviation.

Finally, Wang et al. (2020) evaluate the perceptions of impoverished residents regarding the influence of tourism on poverty alleviation from a multidimensional poverty perspective. Their research indicates that tourism economic development has a substantial impact on the reduction of multidimensional poverty. However, they also recognize that additional promotional initiatives and enhancements are required to further capitalize on these advantages.

In summary, this literature review emphasizes the intricate and multifaceted relationship between poverty alleviation and tourism investment. It highlights the importance of specific policies that consider the changing nature of tourism, local situations, and the quality of leadership to effectively use tourism to reduce poverty.

We still don't fully understand how tourism affects different people and places, even though existing studies have given us important information about how tourism investment can help reduce poverty (Neger et al, 2025). There are not enough detailed frameworks that consider governance quality, reliance on tourism, and different forms of poverty, even though many studies focus on specific areas (Sánchez-Dávila and García, 2025). Furthermore, the long-term poverty reduction strategies in tourism-dependent regions have not been extensively investigated in relation to the impact of global disruptions, such as the COVID-19 pandemic. To develop policies that are effective and responsive to the unique conditions and obstacles of the local area, it is imperative that future research address these gaps.

This study contributes to the literature by showing novel empirical evidence on the relationship between

tourism investment and poverty in Algeria using the Autoregressive Distributed Lag (ARDL) model. As compared to previous studies, which predominantly handled aggregate economic growth or employment in industries, this research specially addresses the effect of tourism investment on poverty alleviation both in the short-run and long-run. By using new evidence and advanced econometric techniques, the paper offers a more nuanced view of the dynamic interactions between these variables. The findings add to policy debate by highlighting tourism as a potential driver of poverty alleviation in Algeria's economic system.

3. DATA OVERVIEW AND METHODOLOGICAL STRATEGY

3.1. Model specification

The dependent variable is regressed on its own past values and the past values of one or more independent variables in the ARDL (Autoregressive Distributed Lag) model. The following is a fundamental description of the ARDL model for a panel dataset, in which y_{it} is the dependent variable and x_{it} represents the independent variables for cross-sectional unit i at time t :

$$y_{it} = \alpha_i + \sum_{p=1}^P \beta_p y_{i,t-p} + \sum_{q=0}^Q \gamma_q x_{i,t-q} + \epsilon_{it} \quad (1)$$

where:

α_i : Cross-sectional fixed effect for unit i .

β_p : Coefficients for the lagged dependent variable Y .

γ_q : Coefficients for the lagged independent variable X .

ϵ_{it} : Error term.

P and Q are the maximum lag orders for Y and X , correspondingly.

The ARDL model can capture both short- and long-term relationships:

1. The coefficients of the lagged dependent and independent variables are indicative of short-term dynamics.
2. You can use an Error Correction Model (ECM) to estimate the long-term relationship once you've established a cointegrating relationship.

When selecting latency orders P and Q for your research, it is important to consider the panel structure, if applicable, as well as criteria such as AIC or BIC.

In this study, the dependent variable is consumption, and an economic model will be estimated to investigate the correlation between household per capita consumption and tourism investment from 1995 to 2020. The objective of this study is to elucidate the influence of tourism investment on household spending, thereby

enabling policymakers to develop policies that increase income and support the national economy through family expenditure. And apply equation 01 in the relationship between variables.

$$\text{LnHpcCON}_{it} = \alpha_i + \sum_{p=1}^P \beta_p \text{LnHpcCON}_{i,t-p} + \sum_{q=0}^Q \gamma_q \text{LnTI}_{i,t-q} + \epsilon_{it} \quad (2)$$

where:

LnHpcCON_{it} : Natural logarithm of the household per capita consumption in Algeria at time t .

$\text{LnTI}_{i,t-q}$: Natural logarithm of the tourism investment in Algeria at time t .

α_i : Cross-sectional fixed effect for unit i .

β_p : Coefficients for the lagged household per capita consumption.

γ_q : Coefficients for the lagged tourism investment.

ϵ_{it} : Error term.

Using the log-transformed numbers allows you to interpret the coefficients as elasticities, displaying the percentage change due to a 1% change.

3.2. Data

Using the Autoregressive Distributed Lag (ARDL) model, this investigation investigates the correlation between poverty and tourism investment in the Algerian economy from 1995 to 2020. To diversify its economy and improve its tourism sector, Algeria is currently examining the impact of fluctuations in tourism investment on poverty levels. We evaluate poverty using the national poverty rate, which provides a comprehensive understanding of the socioeconomic challenges faced by the population. Considering the potential for tourism to generate employment opportunities and promote economic expansion, it is imperative to comprehend its influence on poverty reduction. The study incorporates data from the World Bank and national statistics to quantify tourism investment, which encompasses both domestic investment and foreign direct investment (FDI) in tourism-related sectors. Control variables in the model include inflation, unemployment rates, and GDP per capita, which are crucial for comprehending the broader economic context. The research also examines the potential existence of a threshold effect, as it investigates whether the relationship follows a nonlinear pattern. Table 1 presents the relevant data details for the analysis.

Economic openness was included to cover employment opportunities impacted by trade liberalization, balancing unemployment. Investment in infrastructure was included as it increases productivity while reduc-

Table 1. Variable descriptions and data origins.

Type	Proxy	Variables	Description	Sign	Source
Dependent Variable	LnHpcCON	Household per capita use.	Household per capita consumption		
Independent Variable	LnTI	Tourism Investment	Development and funding of tourism-related facilities and activities.	+	World Bank, 2023
	LnOPNS	Economic Openness	Exports plus Imports divided by GDP	+	
Control Variables	LnINFR	Infrastructure	Fixed telephone and mobile cellular subscriptions per 100 people	+	
	LnGDPpc	Market Size	Gross Domestic Product annual percapita	+	

Table 2. Statistics descriptive.

Proxy	Mean	S/Dev	Max	Min	Jarq-Bera	Prob
LnHpcCON	0.83	0.52	3.04	-0.23	1.72	0.45
LnTI	10.18	1.52	12.25	8.81	2.45	0.17
LnINFR	43.85	39.55	117.21	2.43	5.63	0.073
LnOPNS	53.98	10.46	56.85	23.68	0.57	0.36
LnGDPpc	3.62	3.18	6.20	-1.12	0.75	0.70

Table 3. Matrix of correlation.

Variables	LnHpcCON	LnTI	LnINFR	LnOPNS	LnGDPpc
LnHpcCON	1				
LnTI	0.59	1			
LnINFR	0.52	0.15	1		
LnOPNS	0.87	0.93	0.63	1	
LnGDPpc	0.73	0.42	0.43	0.78	1

ing costs, reducing inflationary pressure. These controls enable a better estimation of the contribution of tourism investment to poverty because they cover overall economic and structural determinants of Algeria.

Table 2 of descriptive statistics reveals the important summary measures for the logarithmic variables. LnHpcCON has an average of 0.83 and a moderate amount of variation, with a standard deviation of 0.52. This suggests that household spending per person is stable. LnTI has a high average value of 10.18 and a low variation, with a standard deviation of 1.52. This means that investment values are close to each other. The S/Dev of 39.55 for LnINFR implies substantial variation and a wide range for the values of infrastructure. LnOPNS (Openness) is moderately variable: S/Dev = 10.46, indicating differences in trade or economic openness. LnGDPpc (GDP per capita) varies significantly, with S/Dev = 3.18, which means economic disparities. The Jarque-Bera statistics indicate data normality across variables: Prob > 0.05.

Table 3 of the correlation matrix shows strong relations among the variables under study. LnHpcCON has a strong positive relationship with LnOPNS (0.87) and LnGDPpc (0.73), implying that the openness of the economy and GDP per capita do matter in consumption. The relationship between LnTI and LnOPNS (0.93) is strong, while the relationship between LnHpcCON (0.59) is moderate, suggesting that the growth of tourism investment heavily depends on openness. LnINFR (infrastructure) moderately correlates with LnHpcCON (0.52) and LnOPNS (0.63), hinting at its supportive role

in consumption and openness. The strong correlation between LnGDPpc and LnOPNS (0.78) strengthens economic interconnectivity. In general, openness emerges as a central influence across variables.

3.3. Methodology

The Autoregressive Distributed Lag (ARDL) model frequently examines the dynamic relationships between variables in time series data. The initial step in the process is to evaluate the order of integration of the variables using unit root tests, such as the Augmented Dickey-Fuller (ADF) or the Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test, to ascertain whether the variables are stationary or I(1) (Pesaran et al., 2001). Next, we use the Akaike Information Criterion (AIC) or the Schwarz Bayesian Criterion (SBC) to find the best latency length for the ARDL model (Pesaran and Shin, 1999). The ARDL model includes both the dependent and independent variables, along with their past values, after figuring out the correct lag length. We estimate the model using ordinary least squares (OLS) to determine the coefficients. After estimating, researchers look at how quickly things balance out by studying the long-term and short-term connections between the variables, including how errors are corrected (Wang and Zhang, 2020). Diagnostic tests, like the Breusch-Godfrey test for autocorrelation and the Jarque-Bera test for normality, are used to ensure the model is valid (Narayan

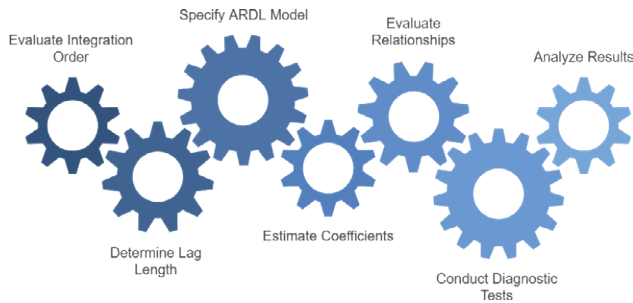


Figure 1. Steps to analyze Time Series data with ARDL. Source: prepared by researchers.

and Narayan, 2004). The results are examined to better understand how the different variables relate to each other (Bashir and Shahbaz, 2020) (see Figure 1).

4. FINDINGS AND ANALYSIS

4.1. Evaluate order of integration

4.1.1. Perform unit root test

The order of integration of all the variables in our study is shown in Table 4, which is based on the findings of the Kwiatkowski-Phillips-Schmidt-Shin (KPSS) and Augmented Dickey-Fuller (ADF) tests for unit root. The findings indicate that all independent variables are integrated into various orders (I(0) and I(1)), whereas the dependent variable (HpcCON) is integrated into order one (I(1)). As a result, neither of the series is integrated into order two (I(2)), as shown by the ADF and KPSS tests. Therefore, we can estimate our model using the Autoregressive Distributed Lag (ARDL) Bounds Testing approach.

4.1.2. Cointegration assessments – ARDL bounds tests

Table 5 displays the statistical results for bound testing in each model, revealing the existence of long-term

Table 5. Calculated F-statistic for cointegration assessments – ARDL bounds tests.

Statistics	Regression	Conclusion
F-S		76.67*
LUB10	3.02-3.51	Cointegration
LUB5	3.62-4.16	
LUB1	4.94-5.58	
K		1

Note: * indicates statistical significance at 1%; ** indicates statistical significance at 5%; *** indicates statistical significance at 10%; F-S: F-statistics; LUB10: Lower-upper bound (10%); LUB5: Lower-upper bound (5%); LUB1: Lower-upper bound (1%); K denotes the quantity of regressors incorporated in the models.

associations. The model has computed F-statistics of 76.67, respectively. These values are higher than the critical upper bound values for the significance level of the model. In particular, the F-statistic exceeds the 1% upper bound critical value of 5.58 for the model. We reject the null hypothesis that there is no cointegration since the F-statistics in both situations are greater than the critical thresholds. This finding suggests that the variables in both models move together over time and offers strong evidence of a cointegrating relationship between them. These results confirm that the model’s cointegration findings are strong and indicate that there are long-term, stable connections in the study.

4.2. Determine optimal lag length

In the analysis of the time series, figuring out the ideal lag length is essential to guaranteeing model accuracy and dependability. A suitable lag time improves forecast accuracy, lowers autocorrelation, and collects crucial historical data. To determine the model’s best-fit lag structure, selection criteria such as AIC, BIC, and HQIC are frequently employed. Table 6 suggests estimating the study model with three-time gaps using the ARDL model.

Table 4. Tests of ADF & KPSS unit Root results.

Test	LnHpcCON	LnTI	LnGDPpc	LnINFR	LnOPNS	
At Level	ADF	-3.44	-4.74	-2.69***	-4.69***	-3.65
	KPSS	1.15	1.37	2.49	2.49	6.46
At 1 st Difference	ADF	-5.17*	-4.17*	-	-	-5.21***
	KPSS	1.081*	1.91*	1.05*	1.65*	1.68*
Order of Integration	I(1)	I(1)	I(0)	I(1)	I(1)	

Note: *, **, and *** signify the rejection of the null hypothesis at the 1%, 5%, and 10% levels, respectively.

Table 6. Establishing the Lag Length Requirement.

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-29.49	-	0.07	3.14	3.24	3.16
1	54.05	142.04*	2.82e-05	-4.80	-4.50*	-4.74
2	57.57	5.26	3.01e-05	-4.75	-4.25	-4.65
3	63.19	7.31	2.66e-05*	-4.91*	-4.22	-4.78*
4	66.66	3.81	3.03e-05	-4.86	-3.97	-4.69

4.3. Estimate the model

4.3.1. ARDL model estimation for the long-run model

The Autoregressive Distributed Lag (ARDL) model can be used to estimate the long-run equilibrium equation once the cointegration relationship between the dependent and independent variables in this study has been confirmed. To comprehend the long-term effects of the independent variable on the dependent variable, as well as the sustainability of their relationship over time, this estimation is an essential step. This study employs two lags to enhance the precision and coherence of the results. Table 7 displays the estimation results for the long-run parameters using the ARDL model. According to predictions, some economic factors might not greatly affect individual spending over the long term. The results show that the effect of household consumption is not important at the 1% significance level. This suggests that other factors might have a longer-lasting, more potent effect. Additionally, the modified R-squared value shows that tourism investment accounts for about 68.2% of the differences in individual consumption levels, which is consistent with the study (Sánchez-Dávila and García, 2025). Given its role in increasing household spending, this emphasizes the significance of tourism investment as a factor in raising individual consumption levels. It implies that encouraging tourism investments may eventually help raise household purchasing power.

Table 7. ARDL model estimation for the long-run model.

Variable	Coef	Std. Error	T-Statistic	P-V
C	0.252	0.245	1.078	0.308
LnHpcCON	1.214	0.014	2.728	0.017
LnTI	3.512	0.026	1.562	0.002
LnINFR	2.523	0.235	1.523	0.041
LnOPNS	3.264	0.324	2.635	0.006
LnGDPpc	2.512	0.235	0.523	0.001
R-Squared	0.682	Adjusted R-Squared		0.589
F-Statistic	3.017	Prob (F-Statistic)		0.031

4.3.2. Calculating the ARDL Model's Error Correction Form (ARDL-ECM)

The Error Correction Model (ECM) is an important tool in ARDL analysis. It helps measure the short-term relationships between variables and determine how quickly they correct to reach a long-term balance. Because it illustrates the degree to which short-term imbalances affect long-term behavior, this model is very helpful in dynamic models. The ARDL model's error correction findings are shown in Table 8. The results of the bound test are confirmed, showing that there is a relationship between the variables. This is supported by the error correction parameter, which is statistically significant at the 1% level and is negative. The error correction coefficient (-0.439) indicates that the current year rectifies about 43.9% of the household spending imbalance from the prior year. After any short-term shocks or imbalances, the variables progressively return to equilibrium over time, as confirmed by this negative, statistically significant coefficient. The results show that the household consumption parameter is very important in the dynamic model, as it is the only one that is statistically significant at the 1% level. This model suggests that short-term changes in personal consumption eventually led to the achievement of the intended equilibrium, which is consistent with the study (Sánchez-Dávila and García, 2025; Neger et al, 2025). With only a small portion of the imbalance being corrected each year, the adjustment speed is rather slow, suggesting that shocks or changes in the economy gradually affect consumption patterns.

Table 8. ARDL Model's Error Correction Form (ARDL-ECM).

Variable	Coef	Std. Error	T-Statistic	P-V
C	-0.563*	1.236	-3.253	0.001
D(LnTI)	2.231**	0.112	2.122	0.015
D(LnINFR)	3.261	0.539	3.147	0.157
D(LnOPNS)	1.254	1.536	2.159	0.132
D(LnGDPpc)	2.489**	0.589	3.259	0.012
D(LnTI)(-1)	2.115*	1.479	1.158	0.005
D(LnINFR)(-1)	3.456*	1.886	4.157	0.002
D(LnOPNS)(-1)	1.356*	0.753	2.428	0.004
D(LnGDPpc)(-1)	2.512*	1.769	1.4258	0.001
CointEq(-1)	-0.439*	0.253	-5.156	0.000

Note: * indicates statistical significance at 1%; ** indicates statistical significance at 5%; *** indicates statistical significance at 10%.

4.4. Conduct diagnostic tests

4.4.1. Lagrange Multiplier test of residual

We used the LM test to check for any serial correlation in the residuals. This helped us ensure that the model we used in the study is valid and has no econometric issues. The purpose of this test is to identify any autocorrelation, which can skew results and impair estimate accuracy. We accept the null hypothesis because, as shown in Table 9, the chi-square value is higher than the 5% significance level. This means that the results are not statistically significant at this level. We therefore draw the conclusion that there are no autocorrelation problems in the residuals of the model. The residuals appear random instead of following a pattern, which means the model gives reliable results and supports the credibility of the findings. As a result, the model’s results and suggestions can be trusted to provide unbiased scientific understandings of the economic relationships under study.

4.4.2. Structural stability test for estimated ARDL model

The cumulative sum of recursive residuals (CUSUM) and the cumulative sum of squares of recursive residuals (CUSUMSQ) tests are crucial for ensuring data stability and excluding any structural changes over time that could compromise the quality of the model. To confirm consistency across time, these tests assess how

stable the model’s short- and long-term parameters are. The CUSUM test shows that the model remains stable, and its parameters stay consistent over time. The cumulative sum line stays within the critical zone limits at the 5% significance level (see Figure 2). The CUSUMSQ test yields a similar result, indicating stability in the squared residuals. This demonstrates that the model attains the required stability, improving the validity and accuracy of the findings by examining the economic linkages being examined and bolstering trust in the study’s conclusions and suggestions.

5. DISCUSSION RESULTS

This analysis agrees with Garza-Rodriguez (2019) that tourism helps local economies grow. It shows a stable relationship between money spent on tourism and the amount of money households spend per person. Additionally, the study shows that investments in tourism have a positive effect on household consumption, which lowers poverty. This is consistent with earlier research, including Cárdenas-García et al. (2024) and Folarin and Adeniyi (2019), which showed that tourism boosts employment and economic growth, and Njoya and Seetaram (2018), which demonstrated that tourism investments raise household incomes in rural areas.

Evidence suggests that by ending the cycle of poverty and bringing financial stability to households, sustainable tourism development not only boosts individual consumption but also advances social and economic development. According to Kronenberg and Fuchs (2021), tourism can be a potent instrument for generating economic opportunities for underserved communities. They stress the significance of integrating local communities, allowing the impoverished to engage in

Table 9. Breusch-Godfrey Serial Correlation LM Test.

F-Statistic	0.85	Prob. F (1,12)	0.37
Obs*R-Squared	1.32	Prob. Chi-Square (1)	0.24

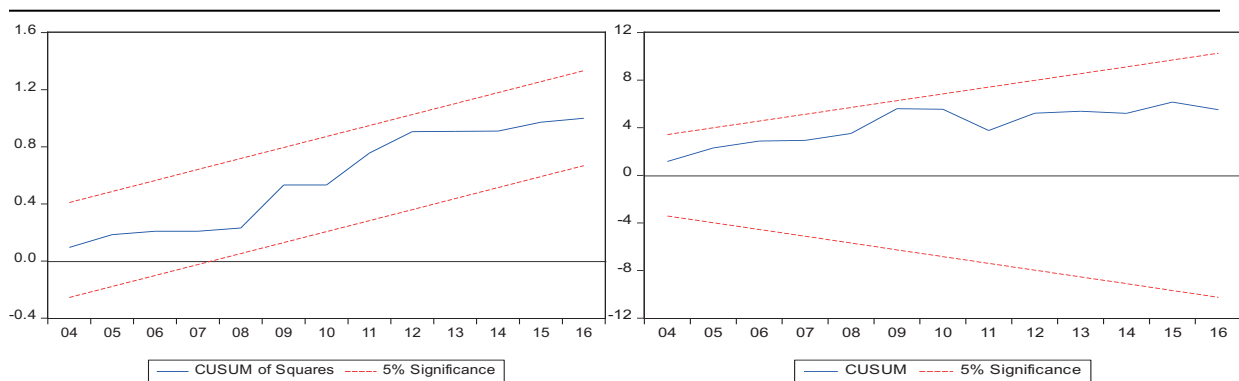


Figure 2. Cumulative sum of recursive residuals (CUSUM and CUSUM of squares) indicates the stability of the model.

the tourism value chain, thereby improving living standards and fostering economic stability.

Policymakers must acknowledge tourism as a viable economic sector to optimize the contributions of tourism investment to the national economy. Since tourism increases demand for a variety of skills and services, resulting in new job opportunities, we stress the necessity of policies that encourage skill development and tourism training (Bhatt et al., 2024). Matiku et al. (2021) agree that for sustainable tourism to bring economic and social benefits, it needs good management of people and natural resources.

The results of this study demonstrate how tourism investment can help lower poverty and raise living standards in local communities, particularly when it is incorporated into larger development plans. To attract tourists and promote foreign direct investment in this industry, governments should make investments in the infrastructure and amenities required. According to Zhang and Yang (2023), tourism has the potential to increase tax income and enhance public services for the benefit of everybody.

In conclusion, tourism investment has the potential to greatly reduce poverty and enhance local populations' quality of life, especially when integrated into national development plans. To make tourism development a more effective instrument for reducing poverty, this study suggests implementing national policies that support sustainable tourism, training skilled human resources to manage the industry, and enhancing synergy between economic sectors.

6. CONCLUSION AND POLICY RECOMMENDATIONS

This study uses the Autoregressive Distributed Lag (ARDL) model to look at both short- and long-term effects of tourism investment on reducing poverty in Algeria. The purpose of this study is to ascertain whether more tourism investment may reduce poverty in Algeria, given the growing importance of tourism as an economic engine. This study examines whether tourism investment has a positive impact on poverty reduction and provides new insights into this relationship by using the ARDL framework. Furthermore, from 1995 to 2020, the report presents both aggregated and disaggregated evaluations of tourism investments across important sectors like lodging, transportation, and infrastructure. We carried out several diagnostic tests to verify the model's accuracy and stability to assure resilience.

The findings show a strong correlation between tourism investment and poverty reduction over the long term,

indicating that higher tourism investment is associated with lower rates of poverty. The results show that investments in the tourism industry have a favorable effect on reducing poverty, especially when it comes to creating jobs and revenue for industry. The findings, however, indicate a range of short-term outcomes, with certain tourism investments exhibiting delayed effects on reducing poverty. Furthermore, compared to other forms of tourism spending, the study finds that infrastructure investments – such as those in lodging and transportation – have a greater long-term impact on reducing poverty.

This study has many limitations even though it offers fresh perspectives on how tourism investment affects poverty. Increased data frequency could reveal more subtle effects. Future research may also be able to capture dynamic shifts in the relationship between tourism investment and poverty by including time-varying factors. To provide more thorough knowledge of the potential of tourism to reduce poverty in developing economies like Algeria, future studies should also take sector-specific studies and investigate additional socio-economic variables.

Policymakers need to enhance tourism investment through the development of infrastructure, creation of employment, and inclusive economic policies to achieve optimal poverty reduction. Because of data constraints, the authorities need to improve data collection and the frequency of reporting to allow more precise analysis. Policies need to be time-dynamic in nature, capturing evolving economic conditions, considering time-varying determinants of tourism and poverty. Investments focusing on sub-sectors such as ecotourism, cultural heritage, and hospitality services can also generate sustainable employment and income opportunities. The inclusion of broader socioeconomic factors, i.e., education and financial inclusion, in the study will lead to better-informed policies. Strengthening public-private partnerships can also support tourism-led poverty alleviation through entrepreneurship and business development. Lastly, policymakers need to incorporate tourism investment in an overall economic diversification plan so that the benefits trickle down to marginalized groups. All these actions will make the sector more effective in stimulating sustainable growth and alleviating poverty in Algeria's economy.

Policymakers should give transportation and lodging infrastructure improvements top priority to use tourism investment to reduce poverty in Algeria, as both sectors have demonstrated significant and beneficial effects on poverty alleviation. Encouraging private sector investment in rural and underserved areas through tax exemptions or subsidies could promote inclusive tour-

ist growth, boosting local revenue and job possibilities. Enhancing tourism and hospitality workforce training initiatives would also guarantee skill development and long-term jobs for local populations. Building partnerships with foreign investors in tourism can bring in more money and expertise, helping the industry grow in the long run and ensuring the benefits are spread fairly.

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Taxation in agriculture: an evaluation of the Italian land cadastre as a tool for identifying incomes in the agricultural sector

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Abstract. Recent tax reforms contributed to developing a seemingly tax-free agricultural sector in Italy. The purpose of this article is to investigate inconsistencies of the cadastral system and analyse whether it contributes to distancing taxation in agriculture from general principles of fairness and economic efficiency. Data from official sources are analysed using a composite research design with four methodological steps, aimed to: *i*) investigate differences between cadastral holders and farms; *ii*) highlight impacts of structural changes in agriculture; *iii*) contrast determination procedures for cadastral and capital incomes; and *iv*) evaluate farmland income as a measure of income and land value. Findings reveal several limitations of the Italian cadastral system as an instrument for measuring land and business income, highlighting a mismatch between property and business income taxation, which makes the distinction between farmland and agrarian income anachronistic.

Keywords: agriculture, land cadastre, taxation, income, Italy.

JEL codes: H20, Q10.

1. INTRODUCTION

Farmers' protests in Italy were recently triggered by the government's choice to stop the exemption of farm incomes from the personal income tax (henceforth, IRPEF, from the Italian acronym "*Imposta sul reddito delle persone fisiche*"), which was introduced in 2016 (Mazzocchi et al., 2024). A new attempt was made to placate the protests using taxation, amending art. 1, paragraph 44 of Law 232/2016¹, to establish new tax exemptions for farm incomes until 2025. Thus, once again, policymakers decided to intervene in a tax system that had already been subject to numerous amendments, distorting cadastral-based taxation and losing sight of the constitutional objectives (Visco, 2024).

¹ Law n. 232/2016, art. 1, paragraph 44 states that farmland and agrarian incomes are not part of the income taxation base for family farmers and professional agricultural entrepreneurs.

The illusion of the cadastral determination of the agricultural income, as opposed to that of any other enterprise that carries out its activities in another economic sector, definitively waned with the reform of Article 2135 of the Italian Civil Code through Legislative Decree No. 99/2004 (Coletta et al., 2009). Since then, the introduction of mechanisms of differentiated exclusion of cadastral tax bases, reserved for certain types of self-employed agricultural entrepreneurs with given characteristics (L. 232/2016), has continued to result in further corporatisation of tax policies in agriculture (Cristofaro, 2015).

The original setting of the Italian cadastre has been maintained since the end of the 19th century², despite repeated interventions. The role of the cadastral system is twofold: it carries out and updates the inventory of real estate with its graphic representation, and it updates and determines taxable incomes (Permanent Committee on Cadastre in the European Union, 2009; Zangheri, 1980).

Over the years, the cadastre has represented an important tool for ensuring a differentiated fiscal charge for the agricultural sector compared with other productive sectors. As a result, a redistribution of income supposedly aimed at producing the effect of rebalancing the remuneration of agricultural input has occurred (Pierri, 2015).

The Italian cadastral system has continued to maintain considerable autonomy from the taxation system outlined in Art. 53 of the Constitution, which would have led to a shift from a real-type tax system to a personal one. However, although cadastral taxation already seemed largely unable to consider taxpayer conditions and therefore somewhat inadequate for such a pivotal role, the application of the first tax reform in 1971 left the preexisting cadastral framework unaltered.

The cadastral system was used for the purpose of thoroughly approximating actual incomes³, an objective partly pursued with the revision of the cadastral valuations for the land cadastre in 1978–79 and of the building cadastre in 1988–89.

Authorised by the Ministerial Decree of January 20, 1990, a new revision of the land cadastre was proposed, which was supposed to have 1988–89 as a reference peri-

od. However, the revision was never carried out because the Parliament, with Law n. 75/1993, subsequently planned to “*establish new criteria for the classification and determination of the land cadastre values that would account for the productive potential of the land*”⁴. This legislation, which aimed to simplify the cadastral system, was not implemented because of the difficulties encountered in the elaboration of criteria and methods aimed at defining homogeneous classes of land productivity and the unrepresentativeness of the database adopted to validate estimations aimed at identifying taxable incomes (Zuccolo, 1993). Finally, the Minister of Agriculture stopped the reform process with a decree, perhaps due to external pressures from those who feared that such a new tariff system would have been excessively detrimental for farmers (Cristofaro, 2015).

Since then, it has been evident to both the academic world and those working in the sector that the old qualification and classification system (established in 1939) and the criteria and methods used as a basis for estimation operations no longer corresponded to modern production systems and actual structural characteristics of farms (Pierri, 2015; Simonotti, 2008). Table 1 lists all the main regulatory procedures for determining cadastral rents related to land in Italy since the beginning of the 20th century.

However, any successive attempt to revise the land cadastre was futile. Furthermore, real-type taxation systems have been progressively reintroduced, leading to the adoption of cadastral incomes as a tax base for real estate, despite the inability of this system to express actual and potential income and/or asset configurations. In such a framework, flat-rate taxation systems characterised by an extreme simplification of accounting obligations have been increasingly adopted in the agricultural sector (Seroglia, 2003).

However, to the best of our knowledge, there is a gap (or at least a lack of updated and comprehensive studies) regarding the ability of the current taxation system in agriculture, which is based on the land cadastre, to capture both income and land value dynamics in light of the structural and regulatory changes that the sector has experienced in recent decades in Italy (Bottarelli, 2017; Ribauda 1995). Accordingly, whether continuous tax concessions and exemptions to farmers are somehow technically sound and coherent with the Italian constitutional goals is not clear.

Therefore, the research objective of this paper is to provide an updated and detailed evaluation of the potential divergence and inconsistencies at stake in the cur-

² L.3682/1886: Messedaglia Law or Law of Land Equalisation, later supplemented by Law 976/1939 (Second General Revision of the Cadastre). For what concerns the estimative operations for tax purposes, it introduced the use of the company balance sheet on existing and ordinary farms and the sum of farmland and agrarian incomes as taxable income.

³ Article 2 of Law 825/1971 stated that “determination of the farmland, agrarian and building incomes (must be carried out) based on cadastral valuation rates regulated in such a way as to ensure, where possible, adherence to actual incomes, except in those cases exhaustively determined, in which the possibility of divergence and the economic characteristics of the income require direct assessment”.

⁴ Law n. 75/1993 Art.1-sexies.

Table 1. Regulatory procedures for determining cadastral rents related to land in Italy over time.

Year	Act of law	Entry into force	Determination of cadastral incomes (amount)		Time reference for cadastral incomes
			Farmland income (R.D.)	Agrarian income (R.A.)	
1939	<i>Regio Decreto n. 589/1939, convertito nella legge 29 giugno 39, n. 976 "revisione generale degli estimi dei terreni"</i>	1939	R.D.	R.A.	1939
1973	<i>D.P.R. 29 settembre 1973, n. 604 - "revisione degli estimi e del classamento del catasto terreni"</i>	1984	R.D.	R.A.	1939
1984	<i>Pubblicazione ed entrata in vigore Nuove Tariffe d'estimo riferite al biennio 1978/79</i>	1984	R.D.	R.A.	1978–1979
1990	<i>Catasto Terreni revisione rendite catastali biennio 1988-89 - D.M. n. 3/355 del 20/01/1990</i>	Not enacted	R.D.	R.A.	1978–1979
1994	<i>Legge n. 724/1994 Art. 31 comma 1 - maggiorazione tariffe d'estimo 1977/78</i>	1995	R.D.+80%	R.A. +70%	1978–1979
2012	<i>Legge n. 228/2012 Art. 225 comma 512 - maggiorazione tariffe d'estimo 1977/78</i>	2013–2014	R.D. +80%+15%	R.A. +70%+15%	1978–1979
		2015–2016	R.D. +80%+30%	R.A. +70%+30%	1978–1979
2016	<i>Legge n. 232/2016 Art 1 comma 44 - Per gli anni 2017, 2018 e 2019 poi prorogato fino al 2023</i>	2017–2023	R.D. +80%+30%	R.A. +70%+30%	1978–79 (Full exemption for CDs and IAPs)
2023	<i>Legge n. 213/2023 e DL 215/2023 - Esenzione imposta Redditi Dominicali ed Agrari per fasce di reddito imponibile</i>	2024–2025	R.D. +80%+30%	R.A. +70%+30%	1979–79 (Full exemption for CDs and IAPs)

rent taxation system for Italian farms, to shed light on the main weaknesses and to identify possible amendments and improvements.

Based on previous studies in this field (Bayer et al., 2018; Golubeva et al., 2021; Kovalchuk et al., 2021), the present work aims to investigate and assess the role of the Italian land cadastre in identifying taxable agricultural incomes and its ability to foster an eventual fair redistribution of wealth to positively affect farm efficiency and productivity. For this purpose, data from several Italian official sources are used to analyse whether and how the taxation of the Italian farming sector is effective.

2. TAXATION FOR THE AGRICULTURAL SECTOR IN ITALY

Despite some weak attempts to introduce individual taxation systems, the agricultural sector continues to apply income taxes on a real basis, generating an unequal taxation system by law. Such a system also applies to land leased for agricultural use⁵: the only case in which rent must be declared is when it amounts to less than 80% of the revalued farmland income⁶. This latter

income is known as *reddito dominicale* in Italy. Moreover, the sector benefits from a special VAT exemption scheme that allows a tax reduction and therefore implies indirect financial support. Additionally, a specific reduction in the taxation of agricultural-related activities was introduced in 2014 through the inclusion of the agrarian income⁷ (known as *reddito agrario* in Italy) of all activities related to the handling, processing and marketing of agricultural products. Finally, between 2016 and 2017, exemptions from the regional production tax (henceforth, IRAP, from the Italian acronym "*Imposta regionale sulle attività produttive*")⁸, from the local municipal tax (named IMU, from the Italian acronym "*Imposta municipale unica*") and from IRPEF for specific farmer categories⁹ were introduced.

represents the amount of income deriving from the ownership of land, regardless of what is farmed there.

⁷ This is the income attributed for fiscal purposes to someone – e.g., owner, householder – who uses the agricultural land.

⁸ This is an Italian local tax that is levied on the value of net production generated by businesses and professionals at an ordinary rate of 3.9 percent. A reduced rate of 1.9 percent applies to those in the agricultural sector. However, since 2017, farmers have been exempted from paying the IRAP, figuratively making this concession equals to 3.9% if compared with the initial ordinary rate.

⁹ Art. 1, paragraph 13 of the Stability Law 2017 (L 232/2016) established that "agricultural land owned and managed by family farmers and professional agricultural entrepreneurs is exempt from IMU, regardless of its location."

⁵ Agricultural land rents are subject to the VAT exemption regime (Article 10, p. 1, n. 8 of the Presidential Decree 633/72).

⁶ This is also referred to as rental income or landlord income and rep-

Table 2. Fiscal pressure and fiscal charge from 2011–2015 in Italy by economic sector (as a share of value added, %).

Item	2011	2012	2013	2014	2015	Average 2011–15
<i>Fiscal pressure</i>						
Agriculture, forestry and fishing	21.5	18.8	16.8	19	19.3	19.1
Other sectors	40.7	43.4	43.3	43.5	43.4	42.9
<i>Fiscal charge</i>						
Agriculture, forestry and fishing	9.6	7	5.6	7.1	7.6	7.4
Other sectors	25.7	28.3	27.8	28.2	28.1	27.7

Source: CREA - Council of Research in Agriculture and Analysis of Agricultural Economics (2017).

Table 3. Tax concessions in the agricultural sector (million Euro).

Items	2017	2018	2019	2020	2021	Average 2017–21
<i>Social security contributions (reductions or exemptions) for:</i>						
Employers and their employees	271	303	118	105	100	180
Self-employed workers	81	80	65	64	62	70
<i>Direct and indirect taxation (reductions) for:</i>						
IRPEF	195	190	193	193	195	193
VAT	448	431	401	361	331	394
Mineral oil tax refunds	990	1.016	1.012	1.022	1.004	1.009
TOTAL	1.984	2.021	1.789	1.745	1.691	1.846

Source: CREA (2023).

The rationale behind these concessions for the agricultural sector has been to support small farms, which are supposedly less able than large farms to manage rural areas and land properly and therefore should be encouraged to maintain their production activity through reduced fiscal pressure and fiscal charge. Fiscal pressure is defined as the ratio of taxes plus social security contributions to GDP (ISTAT, 2025), whereas fiscal charge measures the share of national income absorbed exclusively by tax revenues and is calculated as the ratio of taxes to GDP (Agenzia delle Entrate, 2025).

Estimates from the Yearbook of Italian Agriculture for the period 2011–2015 (Table 2) measure the differential of fiscal pressure and fiscal charge in the primary sector (which includes agriculture, forestry and fishing) compared with other economic sectors.

The data reveal that the fiscal pressure and fiscal charge in the primary sector were 19.1% and 7.4%, respectively, on average, whereas they were 42.9% and 27.7%, respectively, for the other productive sectors. In addition, the table shows that both indicators decreased over time, in contrast to the situation in the other Italian economic sectors.

Table 3 lists and quantifies the amounts of some relevant¹⁰ tax concessions (including allowances and relief) for the Italian farming system.

During the observed period, these overall concessions amounted, on average, to 1.85 billion Euro per year. Data also show that tax refunds on (mostly fossil) fuels represent the main form of benefit for Italian farmers, followed by taxation reductions applied to the VAT (due to the abovementioned special scheme) as well as IRPEF and social security contributions when applied to self-employed workers, such as *coltivatori diretti* (henceforth CD, i.e., family farmers) and professional agricultural entrepreneurs (henceforth IAP, acronym of *imprenditori agricoli principali*).

3. MATERIALS AND METHODS

The research design focuses on several assumptions and is intended to verify the limitations of the cadastral system as a tool for determining the tax base for direct

¹⁰ Data regarding concessions and exemptions for the IMU (i.e., mountain and disadvantaged areas) are not publicly available to our knowledge.

and indirect taxes. These limitations can be traced back to the critical issues described below:

- 1) The divergence between cadastral holders, farms (as defined by the ISTAT) and companies carrying out agricultural activities.
- 2) Effects induced by structural changes in the agricultural sector after 1978–79 (the date of the last revision of cadastral tariffs).
- 3) Divergence of determination procedures between cadastral income and capital income.
- 4) The inconsistency of farmland income as a measure of income and land value in agriculture.

Analyses are mainly based on the regulations in force for the latest revision of cadastral estimates (Law no. 976/1939 and Ministerial Decree 13/12/1979) and the concepts of study farms, farmland income (RD) and agrarian income (RA) (Medici, 1948). Specifically, study farms are defined as those located within a typical municipality of a homogeneous territory (census circle) that has a prevalence or almost the totality of a certain crop quality (e.g., arable land) (Michieli, 1989).

Then, the farmland income corresponds to the land benefit before taxes and is calculated based on the economic balance scheme drawn up by the Italian agricultural economist Arrigo Serpieri (1877-1960), on which cadastral regulations and cadastral tariffs are based, as illustrated below:

$$RD = PLV - (Q_{agr} + Sv + Sa + St + I) = Rpl - Q_f \quad (1)$$

where:

PLV = gross saleable production,

Q_{agr} = depreciation allowance on agricultural capital,

Sv = miscellaneous expenses,

Sa = wages,

St = salaries,

I = interest on agricultural capital,

Rpl = gross farm income, and

Q_f = depreciation of land capital.

Finally, agrarian income is calculated as follows:

$$RA = I + St_d \quad (2)$$

where:

I = interest on agricultural capital, and

St_d = wages for managerial work.

3.1. Analytical approach and data

The approaches adopted to verify the abovementioned potential limitations and weaknesses of the Italian land cadastre are illustrated in detail in Figure 1.

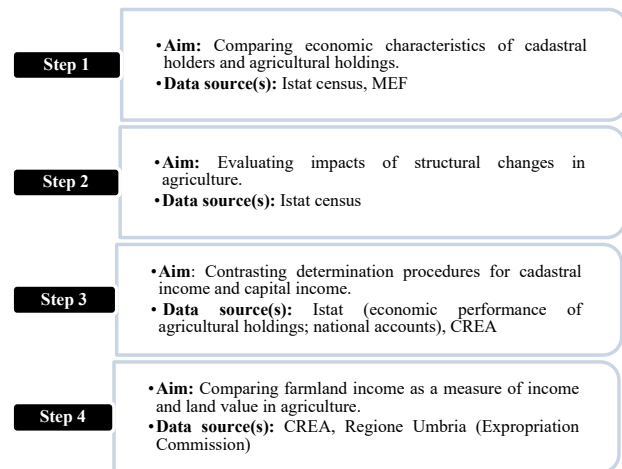


Figure 1. Research design: Methodological steps, aims and data.

The following subsections report a detailed description of the independent procedural steps adopted and implemented for each of the issues under investigation.

3.1.1. Comparing economic characteristics of cadastral holders and agricultural holdings

Based on previous works (Antonietti, 1985; Coletta et al., 2009), the limitations of the cadastral system were tested using available statistical sources to verify the consistency between the principles underlying cadastral taxable values and the structural changes that Italian agriculture has undergone over the past 70 years.

For this purpose, ISTAT data related to the 2020 census were compared with VAT turnover data on Italian agriculture for the year 2020, processed according to the ATECO code. Data were provided by the 'Dipartimento delle Finanze Direzione studi e ricerche economici fiscali' of the Italian Ministry of Economy and Finance (MEF) and were processed separately by year, turnover and type of entity (cooperatives and their consortia, sole proprietorships, corporations and partnerships) that submitted the annual VAT return for 2020.

3.1.2. Evaluating impacts of structural changes in agriculture

After the unification of Italy, the land cadastre was regulated by the Messedaglia Law (Law No. 3682 of March 1, 1886) and Regulation No. 4871 of August 2, 1887. The land tax based on the land registry (i.e., the farmland income) was closely linked to land ownership, reflecting the centrality of land as the main source

of wealth at that time: other types of income (such as labour and capital) were therefore not considered taxable at all. Only later was a tax on movable wealth introduced into the Italian tax system, which charged professions, arts and crafts and was based on self-declaration by taxpayers; in the agricultural sector, for example, it was determined by means of the agricultural tax base (established by Royal Decree No. 16 of January 4, 1923) but introduced only with the revision of the estimates in 1939. However, most of the land at the time was in the hands of capitalist landowners. Therefore, given the small size of the farming property, it was decided not to tax income generated from the work of family farmers (which was somehow categorised as self-employed in the agricultural sector). This principle, which inspired the founding law determining the taxable farmland and agrarian values, remains unchanged today, although it appears anachronistic.

Accordingly, the empirical analysis verifies whether the assumptions underlying the system for the determination of farmland income and agrarian income are fulfilled.

The analysis was structured using the data from the ISTAT agricultural censuses of the last 50 years to investigate whether *i*) the prevalent form of conduct, both in terms of production units and utilised agricultural area, is represented by the family farm and/or professional agricultural entrepreneur as well as whether *ii*) the form of conduct corresponding to the management with wage labour is currently a minority.

A further check was carried out by processing ISTAT aggregate data on the economic performance of farms and those on regular and irregular employment in the agricultural sector for the past decade (2011–2021) to calculate the following equation:

- The ratio of total WU to employee WU.
- The estimate of the average hourly compensation of employees as the ratio of internal employee income, net of social security and insurance contributions, to total employee hours.
- The estimate of the average compensation of employees as the ratio of total employee income, net of contributions, to the number of employees.
- The estimate of total income from self-employment, not subject to taxation, as the ratio of the average hourly remuneration of employees, net of contributions, to the total hours worked by self-employed workers.
- The estimate of the average remuneration of self-employed workers as the ratio of the total value of self-employment income to the number of self-employed workers.

3.1.3. Contrasting determination procedures for cadastral income and capital income

Previous approaches in the literature have been limited to determining taxable income from capital and self-employment based on ISTAT data on national accounts (Coletta et al., 2009). This analysis instead makes use of ISTAT data on the economic performance of agricultural holdings and the value of the fixed capital stock by sector from the national accounts to reconstruct the aggregate taxable value subject to taxation for the period 2011–2021. Specifically, starting from the definitions of farmland income and agrarian income mentioned above, the value of the total taxable income subject to taxation was estimated as follows:

- The values of gross saleable production and variable costs were defined based on the value of production and value added at constant prices (i.e., net of taxes on products and gross of subsidies on products).
- The value of wages and salaries was derived from the domestic compensation of employees in current prices.
- Self-employment incomes were estimated based on the hourly rate of compensation of employees, net of contribution charges for hours worked by self-employed persons derived from national accounts data, multiplied by the hours worked by the self-employed in the sector.
- Depreciation typically represents the loss in value, which is calculated at the current replacement cost, suffered by fixed assets (e.g., machinery, plant, means of transport) during the year due to physical deterioration, obsolescence (loss of economic value of capital goods due to technical progress incorporated into new goods) and insured accidental damage (e.g., fire, accident, shipwreck) (ISTAT, 2025). Specifically, data concerning the depreciation of farm buildings, fixed equipment and land improvements were derived from ISTAT national accounts for the agricultural sector. Depreciation of plants and equipment as well as of multiannual crops was also obtained from the same source.
- The value of interest on agricultural capital was derived by assigning a rate of 2% to half of the value of the sector's net fixed capital stock determined at current replacement prices.
- The same data used to determine cadastral income were then analysed in the form of a step-by-step profit and loss account to show the gross operating surplus net of estimated depreciation.
- Finally, the value of financial transfers from Pillar I CAP interventions provided by the Council of

Research in Agriculture and Analysis of Agricultural Economics (CREA) was added to highlight its impact on taxable income.

3.1.4. Comparing farmland income as a measure of income and land value in agriculture

The failed revision of the cadastral tariffs and unitary rates for farmland income in the two-year period of 1978–79 resulted in continuous attempts to update their values over time through differentiated coefficients to establish direct taxes on income from land, indirect taxes of patrimonial nature (e.g., the *Imposta municipale unica*, IMU) and the transfer of assets by inheritance.

Here, the analysis focused on certain crop qualities of the best agricultural land belonging to a homogeneous territorial area in Umbria to compare the following:

- The taxable land income¹¹ (based on the cadastral system in force) with the values of the land rents recorded by the CREA (2023) regional report on the rental market and from the database of annual rents by type of farm and crop quality in the Umbria Region (CREA, 2025).
- The cadastral values of agricultural land used for the determination of the IMU taxable income¹² and for inheritance purposes, with the average market values derived from the ‘Overview of agricultural values by type of crop of land included in the individual agricultural regions of the provinces of Perugia and Terni, valid for the calendar year 2023’ published by the Regione Umbria (2022) and determined by the Regional Expropriation Commission.

4. RESULTS AND DISCUSSION

Hereafter, we report the findings of the empirical analysis aimed at shedding light on the potential limita-

¹¹ In particular, the taxable farmland income was determined based on the current tax legislation in force according to the subjective characteristics of the taxpayer; thus:

- In the case of a landowner, the farmland income (referred to 1978/79) is revalued by 80 percent and further revalued by 30 percent, yielding a coefficient of increase equal to 2.34 (since $RD * 1.80 * 1.30 = RD * 2.34$);
- In the case where the owner is a direct cultivator or professional farmer, the farmland income (referring to 1978/79) is revalued only by 80 ($RD * 1.80$).

¹² The tax base for the IMU of agricultural land is determined equal to or greater than the farmland income multiplied by 168.75 (number obtained by applying a revaluation coefficient equal to 25% and a multiplier equal to 135). For the inheritance tax, since 2004, the tax base is determined equal to or greater than the farmland income of agricultural land multiplied by 112.50.

tions of the current system of cadastral taxation in Italian agriculture we previously identified and described. Each of the following sections reports evidence related to one of the abovementioned issues under investigation.

4.1. Composition and fiscal framework of farms

The census records of the land cadastre (updated to 2022) include approximately 86 million cadastral parcels, of which more than 60 million are income-producing. The number of cadastral positions¹³ in Italy is more than 6.5 million (accounting for only cadastral parcels associated with farmland and agrarian incomes), in contrast to the 1.133 million farms surveyed by ISTAT (2020) and the 451,734 VAT fiscal positions with ATECO 01.4-digit codes¹⁴. Specifically, agricultural holdings (farms) according to the ISTAT are technical-economic units consisting of land, even in noncontiguous plots, and possibly of various facilities and equipment, on which agricultural activity is carried out, as either the principal or a secondary activity. VAT returns in agriculture identify businesses (natural and legal persons) in the records of the Italian Revenue Agency (*Agenzia delle Entrate*) that carry out agricultural, livestock and forestry activities on a professional basis. Specifically, annual VAT returns in agriculture in Italy identify businesses with turnover exceeding 7,000 euros that have not opted for the exemption scheme. Therefore, the numbers of cadastral companies, farms and VAT fiscal positions in agriculture do not match because taxpayers who declare income from land can be divided into three different categories, which we identified and described by combining ISTAT information (regarding ATECO) and tax statistics (referring to VAT returns), as follows:

- a) Landowners who:
 - Manage property and obtain rents. They are exempt from VAT because they do not carry out business activities and pay income taxes on a cadastral basis regardless of the rent received.
 - Use the land for recreational purposes, i.e., absentee owners. These landowners are exempted from VAT

¹³ They represent individuals who are registered as holders of real estate in the Italian land register.

¹⁴ ATECO is the classification of economic activities adopted by the ISTAT for statistical purposes, i.e., for the production and dissemination of official statistical data. ATECO is the national version of the NACE nomenclature. NACE is the acronym for “*Nomenclature statistique des activités économiques dans la Communauté européenne*” (i.e., the “statistical classification of economic activities in the European Community”) and is the subject of legislation at the European Union level that imposes the uniform use of the classification within all Member States. The ATECO codes from 01.1–01.7 refer to the agricultural sector.

because they do not carry out business activities and pay taxes on income on a cadastral basis.

- b) Landowners who carry out a productive activity that cannot be classified under ATECO codes 01.1 to 01.7 and that ISTAT considers similar to agricultural businesses under VAT exemptions and, therefore, do not have a VAT registration number. They are exempt from any accounting or other obligations. Moreover, they do not appear in the statistical data of VAT returns, and they pay income taxes on a cadastral basis.
- c) Professional agricultural businesses owning or renting all or part of the land they manage, which own a VAT registration number and are classified under ATECO codes 01.1 to 01.7. They pay income taxes on a cadastral basis if they are natural persons (including partnership companies) or on a balance sheet accounting basis if they are legal entities (i.e., corporations¹⁵).

The existence of such a variety of taxpayers who declare income from land explains the numerical differences between the number of cadastral positions, the number of farms surveyed by the 2020 ISTAT census of agriculture, and the number of VAT returns identifying businesses carrying out agricultural, livestock and forestry activities on a professional basis.

For the first two categories, which are numerically predominant, only information on the cadastral taxable income ability is available, and it is therefore almost impossible to measure actual profitability. The third category represents almost one-third of the agricultural companies registered by the ISTAT census and is the only one for which it is possible to evaluate turnover so that the general and sectoral participation in primary production can be weighed.

Accordingly, a more realistic and accurate picture of the companies operating in the agricultural sector on a professional basis can be provided by data referring to the amount of turnover¹⁶ declared for tax purposes from

¹⁵ For limited companies, the standard tax regime is balance sheet taxation. Agricultural limited liability companies may opt for taxation on a cadastral basis (as established by paragraphs 1093–1095 of Article 1 of Law No. 296 of December 27, 2006 – Provisions for the preparation of the annual and multiyear State budget – 2007 Finance Law). Once the option has been made, then the taxpayer is bound to apply the chosen regime for at least three years (Circular 10/E 2010 Revenue Agency).

¹⁶ According to the ISTAT, turnover is defined as “[an economic measure that] includes sales of products manufactured by the enterprise, receipts for processing followed on behalf of third parties, receipts for any nonindustrial services provided to third parties (e.g., commissions, machinery rentals), sales of goods purchased in the enterprise’s own name and resold without processing, commissions and other fees for sales of goods for third parties, gross receipts from traffic and services to third parties. Turnover is required gross of all expenses charged to

different typologies of VAT returns (individuals, companies, and corporations) related to ATECO (Table 4).

On the one hand, the table reveals that individuals represent approximately 80% of the overall number of VAT returns, but they generate only one-third of the overall amount of turnover. On the other hand, although corporations represent only 5.4% of the overall number of VAT returns, they contribute to generating 42% of the overall turnover of the primary sector.

4.2. *Effects of structural changes in agriculture*

Over the last 50 years, both the structure of farms and the characteristics of farmers (and similar entrepreneurial figures) have changed radically. In this context, the structure of land ownership in the first agricultural census (1861) in Italy revealed a prevalence of capitalist holdings, with direct forms of tenancy or coparticipation, and a reduced presence of family farms (i.e., direct management). This productive structure did not require the consideration of taxable income among the self-employed in agriculture, who were in fact excluded from any form of taxation¹⁷.

Moreover, in the second postwar period, data on the distribution of land ownership reveal that private properties with areas greater than 50 hectares accounted for 81% of the national cadastral area¹⁸. Direct management was still low and was represented mainly by small production units.

Later census data from 1961 to 2020 are summarised in Table 5 and reported graphically in Figure 2.

The data reveal that family farms were clearly prevalent in terms of farmland ownership, despite the emergence of self-employed agricultural entrepreneurs, such

clients (e.g., transportation, packaging, insurance) and all indirect taxes on manufacturing, consumption, etc., except VAT invoiced to customers, net of rebates and discounts granted to customers and returned goods. Export tax refunds, interest on arrears, and interest on instalment sales are also excluded.”

¹⁷ Direct taxation on labour, professional and commercial income had been subject to mobile wealth tax since 1877 (T.U. n. 402 of 24 August 1877). By Royal Decree n. 16 of 4 January 1923, the agrarian income earned by the owner from the cultivation of his land, whether directly or under the sharecropping or tenant farming system, as well as the income of the sharecropper or tenant farmer, was subject to the taxation of mobile wealth. To facilitate its determination and with the revision of cadastral valuations in 1939, Royal Decree Law n. 589 of 4 April 1939 established agrarian income as the income from working capital and management labour and resulting from the formation of the valuation rates, excluding the income from manual labour provided by anyone. For this purpose, agrarian income rates were determined per unit area of each quality and class. These basic principles of the mobile wealth tax remained unchanged until the 1950s.

¹⁸ Source: Medici (1956).

Table 4. Breakdown of types of VAT returns by class of turnover (TO) for crops and forestry (2020).

Class of TO	Individuals				Association or partnership				Corporation				Overall			
	N.	%	TO € (000)	%	N.	%	TO € (000)	%	N.	%	TO € (000)	%	N.	%	TO € (000)	%
TO less than 0 €	127	0.0%	-951	0.0%	23	0.0%	-1,201	0.0%	14	0.1%	-288	0.0%	164	0.0%	-2,440	0.0%
TO equals to 0 €	35,916	10.0%	0	0.0%	7,270	12.2%	0	0.0%	7,074	29.2%	0	0.0%	50,260	11.3%	0	0.0%
TO from > € 0 to > € 100,000	276,474	76.8%	7,009,356	33.5%	28,681	48.1%	977,058	6.4%	8,492	35.0%	269,181	1.0%	313,647	70.7%	8,255,594	13.2%
TO from > € 100,000 to < € 500,000	42,383	11.8%	8,451,101	40.4%	16,547	27.8%	3,938,000	25.9%	4,464	18.4%	1,074,242	4.1%	63,394	14.3%	13,463,344	21.5%
TO from > € 500,000 to < € 2,000,000	4,773	1.3%	4,095,730	19.6%	5,791	9.7%	5,479,337	36.0%	2,158	8.9%	2,221,915	8.4%	12,722	2.9%	11,796,982	18.9%
TO from > € 2,000,000 to < € 5,000,000	391	0.1%	1,167,364	5.6%	1,046	1.8%	3,128,929	20.6%	1,124	4.6%	3,532,612	13.4%	2,561	0.6%	7,828,905	12.5%
TO from > € 5,000,000 to < € 10,000,000	32	0.0%	187,393	0.9%	183	0.3%	1,225,703	8.1%	431	1.8%	3,127,386	11.9%	646	0.1%	4,540,481	7.3%
TO from > € 10,000,000	0	0.0%	0	0.0%	33	0.1%	465,278	3.1%	504	2.1%	16,158,382	61.2%	537	0.1%	16,623,660	26.6%
TO - overall	360,096	100.0%	20,909,992	100.0%	59,574	100.0%	15,213,104	100.0%	24,261	5.5%	26,383,429	42%	443,931	100.0%	62,506,525	100.0%

Source: our elaboration on Ministry of Economy and Finance (MEF) data (2020).

as professional agricultural entrepreneurs and similar subjects. Taken together, these latter categories represent a sort of tax-exempt category both within the agricultural sector and compared with other small self-employed entrepreneurs in the manufacturing and service sectors, which are instead subject to personal taxation systems.

Furthermore, data on employment in the agricultural sector by labour positions as identified in the ISTAT national accounts (and broken down by labour units and hours worked) indicate an agricultural sector where self-employed workers predominate (Table 6).

The table also shows that the annual work units (AWUs) of employees in the primary sector represent approximately one-fifth of the total number of AWUs in the period 2011–2017. Moreover, their hours of employment represent approximately one-third of the total number of working hours from 2020–2021.

Therefore, the taxation of agricultural incomes under the current cadastral system neglects the remaining amount (i.e., two-thirds) of working hours, thus excluding self-employment income in the agricultural sector. In this context, self-employed workers in agriculture are also the main beneficiaries of the income support offered by the first pillar of the Common Agricultural Policy (CAP), which results in a high level of transfer inefficiency (Ciliberti et al., 2022). In this regard, importantly, the selection of cadastral quantification for entrepreneurial income was, at the time, a political choice. Cadastral incomes do not reflect actual incomes, as they are the result of political decisions made almost a century ago (1939) in an entirely different economic context (where the Common Agricultural Policy had not yet been launched).

Moreover, the revision of the civil law system (introduced by Legislative Decree N. 228/2001 on the orientation and modernisation of the agricultural sector) has not been followed by a real harmonisation of the taxation process. In fact, the taxable incomes stemming from all the so-called “connected” activities in agriculture (i.e., processing and/or selling of agri-food products) have mostly been incorporated within the traditional agrarian taxable amount.

Because of the lack of tax harmonisation, a substantial difference in tax treatment persists for the following reasons:

- Agricultural activities recognised as such for civil law purposes but not for tax purposes.
- Agricultural activities absorbed by the agrarian cadastral taxable amount.
- Other agricultural activities that, although recognised for tax purposes as agricultural activities, are not absorbed by the cadastral taxable amount and

Table 5. Farms and farmland by form of management.

Form of management	CENSUS 1961		CENSUS 1982		CENSUS 2000		CENSUS 2010		CENSUS 2020	
	Farms	Farmland (ha)	Farms	Farmland (ha)	Farms	Farmland (ha)	Farms	Farmland (ha)	Farms	Farmland (ha)
Direct management	3,485,968	13,218,237	3,063,010	16,597,798	2,457,960	13,868,478	1,546,507	12,927,680	1,047,976	12,298,323
Management with wage labour	330,060	9,158,660	152,250	6,209,702	132,935	5,706,993	66,490	2,323,913	81,679	3,029,486
Sharecropping	316,549	3,125,536	39,550	389,274	1,487	17,242	-	-	-	-
Other forms of management	161,347	1,069,132	15,750	363,150	708	14,381	7,887	1,829,506	16,059	1,197,664
Total	4,293,924	26,571,665	3,270,560	23,559,924	2,593,090	19,607,094	1,620,884	17,081,099	1,145,714	16,525,473

Form of management	CENSUS 1961		CENSUS 1982		CENSUS 2000		CENSUS 2010		CENSUS 2020	
	Farms	Farmland (ha)	Farms	Farmland (ha)	Farms	Farmland (ha)	Farms	Farmland (ha)	Farms	Farmland (ha)
Direct management	81%	50%	94%	70%	95%	71%	95%	76%	91%	74%
Management with wage labour	8%	34%	5%	26%	5%	29%	4%	14%	7%	18%
Sharecropping	7%	12%	1%	2%	0%	0%	-	-	-	-
Other forms of management	4%	4%	0%	2%	0%	0%	1%	11%	1%	7%
Total	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Source: our elaboration on ISTAT data.

Table 6. Main annual national accounts of aggregates and employment for crop and animal production, hunting and related services.

Crop and animal production, hunting and related services	2011	2013	2015	2017	2020	2021
AWU (annual working units) – total	969,074	992,157	853,686	830,000	N/A	N/A
AWU (annual working units) – employees	185,946	206,635	196,921	172,000	N/A	N/A
Employees (000)	N/A	407.5	423.8	449.3	453.5	453.4
Self-employed workers (000)	N/A	463.7	461.2	443.8	423.6	415.9
Internal income from employment (millions of €)	6,643.6	6,770.5	7,564.7	8,116.2	8,679.8	9,010.2
Employee remuneration - net of contributions (millions of €)	5,407.9	5,588.4	6,223.3	6,642.5	7,125.7	7,369.7
Hours of employment (000)	658,315.9	644,644.7	673,917.1	727,506.6	717,818.4	741,436.6
Employees estimated average hourly wage (€/h)	8.2	8.7	9.2	9.1	9.9	9.9
Employees estimated average income (€/per capita)	N/A	1,582.0	1,590.2	1,619.2	1,582.8	1,635.3
Self-employed working hours (000)	1,627,075.0	1,548,560.2	1,614,245.5	1,562,139.3	1,484,639.9	1,531,523.9
Estimated self-employment incomes (millions of €)	13,366.0	13,424.4	14,906.8	14,263.1	14,737.8	15,223.0
Estimated self-employment average income (€/per capita)	N/A	28,950.6	32,321.7	32,138.6	34,791.9	36,602.5
Total working hours (000)	2,285,390.9	2,193,204.9	2,288,162.6	2,289,645.9	2,202,458.3	2,272,960.5

- whose taxable income is determined at a diversified flat rate.
- Agricultural activities that do or do not require the presence of instrumental inputs and that are subject to both separate taxation and the Italian tax for indivisible public services (i.e., TASI, acronym of *tributo per i servizi indivisibili*)¹⁹; and
- Agricultural land that, to all intents and purposes, is an instrumental asset, subject or not subject to the land tax (IMU) according to its altitude and the entrepreneurial subject that holds it.

subject to TASI and that do not fall within the same production range as the agricultural business (e.g., sale of potatoes at a fruit farm shop) are subject to separate taxation, even though they fall within the scope of the marketing and promotion of agricultural products provided for in Article 2135 of the Italian Civil Code.

¹⁹ The marketing and sale of agricultural products in business facilities

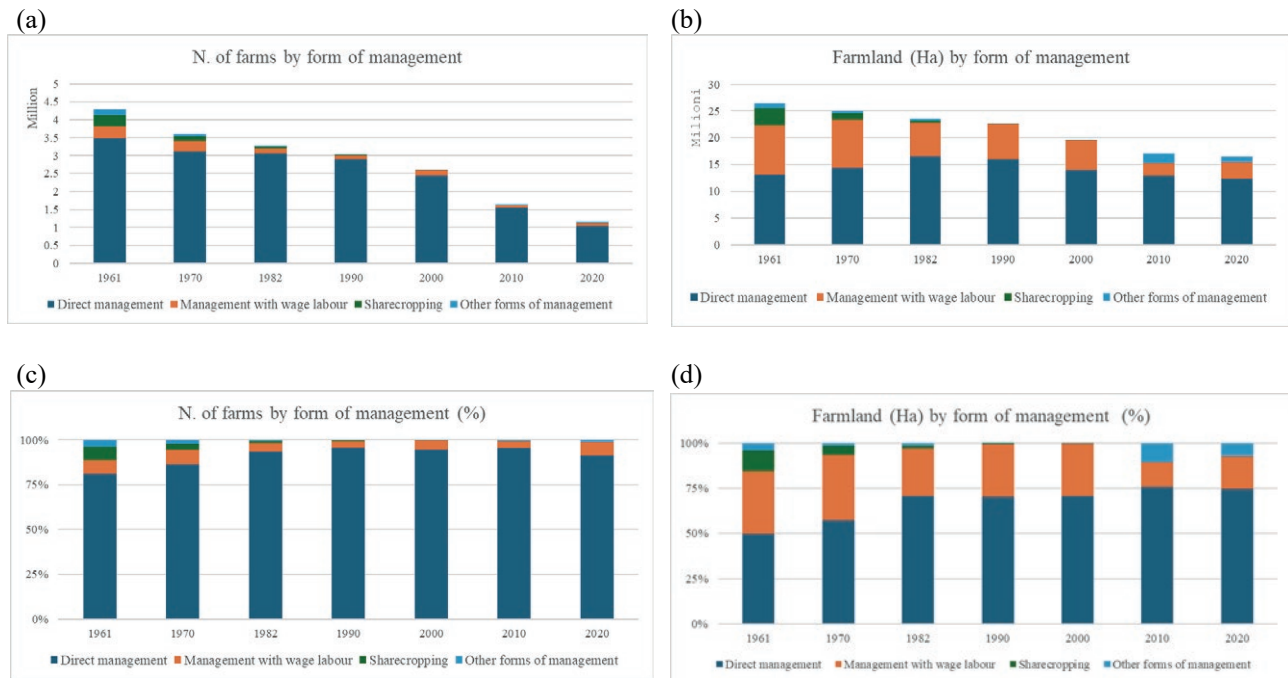


Figure 2. Farms (a, c) and farmland (b, d) by form of management.

Apart from the activities “connected” to agriculture, which are not absorbed by the cadastral taxable amount, the main distorting element of taxation in agriculture is how cadastral rates are determined. Indeed, they still tend to be used as a tax base with differentiated multiplier coefficients that are logically disconnected from both the reality and the structural changes that agriculture has undergone since the last revision of the cadastral rates.

As already mentioned, for the purposes of determining the taxable cadastral value, cadastral income is currently increased by different coefficients depending on whether the owner is an agricultural entrepreneur or a family farmer and/or a professional agricultural entrepreneur. However, such a differentiation does not appear logical in terms of tax consistency. Farmland income constitutes, in fact, the taxable base of land capital alone, which is deployed in a virtually identical manner by the various types of entrepreneurs subject to taxation. In contrast, the distinctive elements that differentiate these types of entrepreneurs are the prevalence of time spent and/or income earned from agricultural activities. However, counterintuitively, this latter aspect does not contribute to determining the taxable amount.

4.3. Effects of income dynamics in agriculture

The 1939 revision of the land valuations focused on the determination of land rent, which was deduced from

units of production considered homogeneous and representative in terms of the production type and system. It follows that cadastral land taxation measures a differential of land income resulting from the use of production factors, which are barely in line with the reality of production or the changes introduced by agricultural policies since 1978 (Ceccaroni Cambi Voglia and Venzi, 1997).

Some statistical data taken from ISTAT national accounts (Table 7) clarify whether the system of cadastral income determination is detached from reality and from the level of capital income it should measure to properly achieve the goal of fiscal equalisation.

The analysis demonstrates the inability of the cadastral system to measure the contributory and earning capacity of the agricultural production sector. In the absence of EU contributions in the form of income compensation, the earning capacity of the sector is characterised by negative capital income as a whole and by a significant share of self-employment income that the cadastral system, as it was conceived, is unable to consider and tax.

Furthermore, Table 8 shows the results of another analysis based on data taken from national accounts for the period 2011–2021. The findings show that, over the period observed, the production sector generated an average annual taxable income estimated at 14.738 million Euro. This latter is mostly determined by the self-employment income of farm owners and/or their unpaid

Table 7. Components of income in agriculture from crop and animal production, hunting and related services (million €).

Item	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	Average
Gross saleable production (current values, production in constant prices)	52,296.7	54,266.3	57,020.3	54,319.0	55,460.6	53,466.80	55,781.20	56,944.80	57,124.80	56,711.80	60,660.10	55,822.9
Variable costs (gross saleable production – value added in constant prices)	24,156.7	24,996.2	25,174.1	24,499.0	24,087.4	23,668.50	24,369.10	25,410.50	25,702.30	26,130.00	28,978.80	25,197.5
Wages (employee income)	6,643.6	6,858.1	6,770.5	7,145.4	7,564.7	7,777.20	8,116.20	8,292.70	8,442.30	8,679.80	9,010.20	7,754.6
Self-employment income (estimated)	1,3366.0	13,281.8	13,424.4	14,190.9	14,906.7	14,654.28	14,263.12	14,372.51	14,919.07	14,737.85	15,222.98	14,303.6
Depreciation of plant and equipment	€ 4,653.2	€ 4,791.5	€ 4,686.6	€ 4,676.1	€ 4,696.3	€ 4,673.3	€ 4,786.5	€ 4,944.9	€ 5,134.6	€ 5,090.1	€ 5,365.2	€ 4,863.5
Depreciation of multiannual crops	€ 347.1	€ 340.7	€ 331.8	€ 344.1	€ 343.5	€ 347.6	€ 346.1	€ 338.9	€ 335.9	€ 327.9	€ 339.6	€ 340.3
Depreciation of farm buildings, fixed equipment and land improvements	€ 6,331.2	€ 6,291.0	€ 6,171.4	€ 6,044.4	€ 5,917.4	€ 5,806.3	€ 5,739.8	€ 5,730.6	€ 5,639.5	€ 5,564.8	€ 5,727.6	€ 5,905.8
Capital income	-€ 3,201.1	-€ 2,293.0	€ 461.5	-€ 2,581.0	-€ 2,055.5	-€ 3,460.4	-€ 1,839.6	-€ 2,145.3	-€ 3,048.9	-€ 3,818.6	-€ 3,984.3	-€ 2,542.4
Interest on advance capital (2% for 6 months)	€ 421.3	€ 432.8	€ 369.6	€ 427.1	€ 426.1	€ 422.7	€ 433.6	€ 447.2	€ 452.5	€ 457.9	€ 494.2	€ 435.0
Interest on inventories (2%)	1,752.7	1,735.1	1,677.4	1,629.6	1,585.1	1,549.37	1,539.49	1,548.20	1,546.84	1,525.62	1,583.58	1,606.6
Farmland income	-€ 5,375.2	-€ 4,460.9	-€ 1,585.5	-€ 4,637.7	-€ 4,066.7	-€ 5,432.5	-€ 3,812.7	-€ 4,140.7	-€ 5,048.3	-€ 5,802.2	-€ 6,062.1	-€ 4,584.0
Wages for managerial activity (2% of production value)	1,045.9	1,085.3	1,140.4	1,086.3	1,109.2	1,069.34	1,115.62	1,138.90	1,142.50	1,134.24	1,213.20	1,116.5
Agrarian income	€ 3,220.0	€ 3,253.3	€ 3,187.4	€ 3,143.1	€ 3,120.5	€ 3,041.4	€ 3,088.7	€ 3,134.3	€ 3,141.9	€ 3,117.8	€ 3,291.0	€ 3,158.1
Cadastral taxable income	-€ 2,155.2	-€ 1,207.7	€ 1,601.9	-€ 1,494.6	-€ 946.3	-€ 2,391.0	-€ 724.0	-€ 1,006.4	-€ 1,906.4	-€ 2,684.4	-€ 2,771.1	-€ 1,425.9

Source: our elaboration on ISTAT data.

Table 8. Taxable incomes of enterprises in the agricultural sector based on national account data for crop and animal production, hunting and related services (million Euro).

Items	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	Average
Gross saleable production (current values, production in constant prices)	52,296.7	54,266.3	57,020.3	54,319.0	55,460.6	53,466.8	55,781.2	56,944.8	57,124.8	56,711.8	60,660.1	55,822.9
Variable costs (gross saleable production - value added in constant prices)	24,156.7	24,996.2	25,174.1	24,499.0	24,087.4	23,668.5	24,369.1	25,410.5	25,702.3	26,130.0	28,978.8	25,197.5
Value added (VA)	28,140.0	29,270.1	31,846.2	29,820.0	31,373.2	29,798.3	31,412.1	31,534.3	31,422.5	30,581.8	31,681.3	30,625.4
Wages (employee income)	6,643.6	6,858.1	6,770.5	7,145.4	7,564.7	7,777.2	8,116.2	8,292.7	8,442.3	8,679.8	9,010.2	7,754.6
Social contributions payable by the tenant and family members	1,574.0	1,653.0	1,694.0	1,778.0	1,735.0	1,735.0	1,735.0	1,735.0	1,735.0	1,735.0	1,735.0	1,713.1
Gross operating margin (GOM)	19,922.4	20,759.0	23,381.7	20,896.6	22,073.5	20,286.1	21,560.9	21,506.6	21,245.2	20,167.0	20,936.1	21,157.7
Gross operating surplus	24,728.9	25,572.9	28,044.0	25,412.7	26,629.4	24,780.5	26,005.2	25,829.4	25,518.2	24,447.1	25,177.8	25,649.6
Depreciation	11,872.8	11,941.9	11,675.6	11,517.9	11,398.1	11,245.4	11,274.0	11,400.2	11,494.5	11,346.6	11,796.7	11,542.2
Taxable income	12,856.1	13,631.0	16,368.4	13,894.8	15,231.3	13,535.1	14,731.2	14,429.2	14,023.7	13,100.5	13,381.1	14,107.5
Subsides from CAP First Pillar in Italy	4,806.5	4,813.9	4,662.3	4,516.1	4,555.9	4,494.4	4,444.3	4,322.8	4,273.0	4,280.1	4,241.7	4,491.9

Source: our elaboration on ISTAT data.

or non-transparently remunerated assistants. In other words, these results show that the primary sector is able to generate significant labour and capital income that is generally not subject to taxation, confirming previous evidence from Coletta et al. (2009). Moreover, this economic performance further improves when the value of income financial support under the first pillar of the CAP is considered.

All in all, the findings confirm previous evidence that the Italian land cadastre provides a tax base that is inadequate *vis à vis* the current profitability framework of the agricultural sector (Colombo, 2003; Pierri, 2015). Additionally, the inadequacy of the IRPEF levy from cadastral-determined entrepreneurial income in comparison to the increasing amount of farmland managed by individuals who are self-employed in agriculture supports the argument of an excessive benevolence of the national fiscal authorities regarding agriculture.

To achieve transparency and better equalise the taxation system in agriculture, it would be necessary to shift to the evaluation of forms of taxation of both capital income and self-employment income in agriculture to reveal other tax bases often hiding forms of exploitation and undeclared work in agriculture²⁰. Currently, however, the fiscal irrelevance for agricultural companies of the cost of fixed-term dependent labour and/or seasonal workers does not allow undeclared work in agriculture to be discovered, with negative consequences in terms of social security contributions and taxable incomes.

4.4. Effects of the dynamics of land values in agriculture

Finally, another fundamental aspect relates to the use of farmland income rates to define land values for inheritance and the IMU tax base for land in no mountainous and disadvantaged areas held by nonexempt persons (provided that they operate in the agricultural production sector).

The proliferation of differentiated coefficients and the corporatisation of tax policies have led to objective criticism for at least two reasons:

²⁰ Agriculture is widely recognised as one of the economic sectors most characterised by the phenomenon of informal or undeclared work resulting in the nonpayment or partial payment of taxes and social security contributions. This is a social problem that cyclically re-emerges despite being a subject of debate for over 50 years. Efforts to fight this issue by ministerial decree or with inspections by the National Labour Inspectorate have never proved to offer an effective solution, and the phenomenon remains widespread throughout the country and reaches critical levels in Southern Italy, where Eurispes estimated the incidence of undeclared work in agriculture at 31.7% in 2013.

Table 9. Comparison between a) tax bases for IMU and inheritance taxable values and regional agricultural values and b) taxable bases for IRPEF and rents in derogation (values in €/ha).

Crop quality	Umbria - municipalities – Homogeneous agricultural region n. 7 (2021–2022)	Class	Farmland income (1978/79) – [A]	IMU tax base [A*1.25.135]	Tax base for inheritance tax [A*112.5]	Agricultural values (Umbria Region – 2023)	IRPEF tax base – Farmland income (landowners) [A*1.8*1.3]	IRPEF tax base – Farmland income (family farmers and professional agricultural entrepreneurs) [A*1.8]	Rents
Irrigated arable crop	Bastia	1	90.4	15,251.62	10,167.7	25,000	211.5	162.7	750.0
	Bastia	2	72.3	12,201.29	8,134.2	22,000	169.2	130.1	600.0
	Cannara	1	72.3	n.a.	8,134.2	25,000	169.2	130.1	750.0
	Deruta	U	82.6	n.a.	9,296.2	25,000	193.4	148.7	750.0
	Torgiano	U	82.6	n.a.	9,296.2	25,000	193.4	148.7	750.0
	Bettona	U	82.6	n.a.	9,296.2	25,000	193.4	148.7	750.0
Average value	:	:	80.5	:	9,054.1	24,500	188.3	144.9	725.0
Arable crop	Bastia	1	74.9	12,637.05	8,424.7	18,000	175.2	134.8	400.0
	Bettona	1	61.9	n.a.	6,972.2	18,000	145.0	111.6	455.0
	Cannara	1	61.9	n.a.	6,972.2	18,000	145.0	111.6	450.0
	Deruta	1	61.9	n.a.	6,972.2	18,000	145.0	111.6	450.0
	Torgiano	1	61.9	n.a.	6,972.2	18,000	145.0	111.6	450.0
Average value	:	:	64.6	:	7,262.9	18,000	151.1	116.2	441.0
Arable crop	Bastia	2	56.8	8,589.71	6,391.2	16,000	132.9	102.3	350.0
	Bettona	2	46.5	n.a.	5,229.1	16,000	108.8	83.7	350.0
	Cannara	2	46.5	n.a.	5,229.1	16,000	108.8	83.7	400.0
	Deruta	2	46.5	n.a.	5,229.1	16,000	108.8	83.7	350.0
	Torgiano	2	46.5	n.a.	5,229.1	16,000	108.8	83.7	300.0
Average value	:	:	48.6	:	5,461.5	16,000	113.6	87.4	350.0

n.a. = not applied.

Source: Our elaboration on ISTAT data, CREA (2025) and the Regional Expropriation Commission for Umbria (2022).

- The tax bases of the different indirect taxes for determining land values are incomprehensibly differentiated, and
- The cadastral incomes are determined by differential classes of merit, which were conceived in 1937–39, without considering the evolution of technologies in the current economic context.

The consistency between the cadastral value and the value of agricultural land is shown in Table 9, where, for the best arable land in Umbria (belonging to the same homogeneous agricultural region in municipalities bordering the Tiber Valley), we compared the following:

- The tax value determined based on the farmland income, multiplied by differentiated coefficients for the purposes of paying property taxes (i.e., IMU) and for the purposes of declaring mortgage, cadastral and inheritance taxes.
- The regional agricultural values for the calendar year 2023, determined by the Regional Expropriation Commission.
- The unit taxable value of the farmland income for the corresponding crop quality, revalued in a differentiated manner and used for the purposes of paying income tax by both landowners and those classified as family farmers or professional agricultural entrepreneurs.

The comparison between tax values and the prudential reference values determined by the Regional Expropriation Commission revealed a significant undervaluation of the tax value for inheritance purposes compared with the value of the land (with differences ranging from €10,000 to €15,000 per hectare, compared with an average land value of approximately €20,000 per hectare). This phenomenon causes a generalised benefit for all land ownership, regardless of the form of management. These results are perfectly in line with those of Agosta et al. (2022) and Ascuito et al. (2008), who reported that tax values were consistently lower than market prices in Sicily. Empirical evidence therefore confirms a considerable discrepancy between these two economic parameters due to the erroneous quantification of the multiplier coefficients used to calculate tax values from the revalued farmland incomes.

To summarise the phenomena under investigation, Figure 3 - Panel a shows that taxes due by landowners, dedicated to the mere management of land assets on the plains benefitting from rents, are established based on a taxable income defined on a cadastral basis, which, for the plains of Umbria, is, on average, equal to 30% of the rent. Conversely, family farmers and professional agricultural entrepreneurs pay taxes on land taxable income that is defined on a cadastral basis, which corresponds, on average, to 23% of the use value of land (i.e., the ordi-

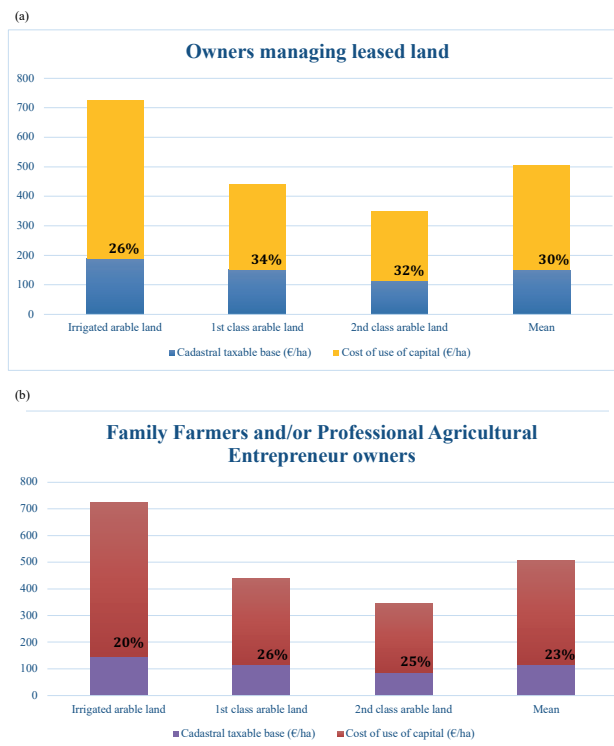


Figure 3. Comparison between the cadastral tax base and the cost of capital use for (a) landowners managing leased land and (b) family farmers and professional agricultural entrepreneurs.

nary rent) of the land owned for representative irrigated arable crops in Umbrian plain areas.

Moreover, in both cases, in the case of *mortis causa* succession, family farmers and professional agricultural entrepreneurs pay cadastral, mortgage and inheritance taxes based on a taxable income defined on a cadastral basis that ranges from 37–41% of the normal agricultural value for irrigated plain land in Umbria. Thus, the discrepancy between the cadastral taxable amount and the normal value reduces the taxation of both cadastral mortgage taxes and transferred assets.

In other EU countries, the levy on income in the agricultural sector for tax purposes is quite similar to those in other economic sectors. It differs in some cases for flat-rate systems by type of enterprise; the only state that continues to adopt the cadastral system for determining direct taxes is Italy (Seroglia, 2003).

Table 10 summarises the different regimes for determining the tax bases for some EU countries in relation to personal income taxation and wealth, inheritance and registration taxes.

What emerges is that, except in the case of the VAT, for which there is currently a certain degree of uniformity in Europe owing to harmonisation policies, the struc-

Table 10. Criteria for determining the tax base: a comparison across some EU countries.

Country	Income tax	Property tax	Inheritance tax	Tax on real estate transaction (registration tax)
Austria	Incomes – Flat rate for small enterprises	Cadastral value	Cadastral value	Market value
Belgium	Incomes	N/A	Market value and cadastral value	Market value
Denmark	Incomes	Market value	Market value	N/A
Finland	Incomes	Market value	Conventional value	Market value
France	Incomes	Cadastral value	Market value with benefits for agriculture	Market value with benefits for agriculture
Germany	Incomes – Flat rate for small enterprises	Conventional value	Conventional value	Market value with benefits for agriculture
Greece	Incomes	N/A	N/A	Market value
Italy	Cadastral value	Cadastral value with benefits for agriculture	Cadastral value	Market value with subsidised rates
The Netherlands	Incomes	Market value	Market value	Market value
Portugal	Incomes – Flat rate for small enterprises	Market value	Cadastral value	Market value
Spain	Incomes	N/A	Market value (if higher than cadastral value)	Market value (if higher than cadastral value)
Sweden	Incomes	N/A	Market value	Market value

Source: own elaboration on Cristofaro (1997; 2017) and van der Veen et al. (2007) – N/A: information not available.

ture of the individual taxes is diversified across the EU countries under analysis. However, taxation in agriculture is predominantly oriented towards normal cost and revenue regimes and is not differentiated from taxation in other production sectors.

The case of taxes on assets or on the transfer of real estate rights is different; however, cadastral or conventional values offer a useful reference for simplifying the determination of the taxable amount subject to levies. One interesting case is represented by the Austro-Hungarian cadastre (called the “property tax cadastre”), from which Italy derived its cadastral system of assessment and determination of the land valuation rate. It lost its initial function of reference for the calculation of the Austrian property tax in 1968 due to fiscal reforms. In this case, the so-called *Einheitswert*, or “Austrian cadastral value,” is adopted to calculate the tax base for property taxes. Specifically, it has been updated to 1 January 2023 for agricultural and forestry property and attached business premises. Moreover, for indirect taxes, the *Einheitswert* is used only in the case of land transfers to direct descendants, ascendants, and relatives and in the case of inheritance; in all other cases, the taxable amount is determined by the actual amount paid.

Finally, the table reveals that incomes from agricultural activity are taxed based on profits, even if in different ways.

5. FINAL CONSIDERATIONS AND RECOMMENDATIONS

Originally, cadastral incomes were introduced to simplify the taxation process for those working in the agricultural sector by assigning an ordinary income for specific territorial districts and types of farming. These incomes were intended to remain stable for long periods (at least 10 years). However, such an approach based on average sectoral income does not fit with the characteristics of the current Italian agricultural context, which is largely multifaceted and where profitability increasingly depends more on business models (including or not directly processing and selling agricultural products or providing a wide range of services) than on types of farming and geographical location. In detail, several limitations of the Italian cadastral system as an instrument for measuring land and business incomes emerged throughout this work, which can be summarized as follows:

- The structural data of agricultural holdings by type of management confirmed the predominance of direct management across farms. This fact is also proven in numerical terms by the distribution of VAT returns by turnover class and type of enterprise. Thus, the determination of business income through the cadastral taxable amount brought to the exclusion from any form of taxation of those

incomes earned by self-employed agricultural entrepreneurs (either landowner or tenant).

- The analysis of national accounts for the period 2011–2021 showed that the agricultural sector generated an estimated annual taxable income of around €15 billion on average, mainly determined by the self-employment income of farm owners and their families, which is not subject to any form of taxation.
- Farm incomes have not grown uniformly across the different regions of the country since the revision of the cadastral valuations for the land cadastre in 1978–79. Thus, no plausible argument can still support the hypothesis of a revision of the tax base linked to the application of multiplier coefficients rather than to a comprehensive revision of the taxation system based on the results of accurate business studies.
- The decision to tax the agricultural sector through systems based on average ordinary incomes has led over time to a significant divergence between cadastral income values and market values, because of the inadequacy of both the multiplier coefficients and the cadastral rents vis à vis the profound changes that have taken place in Italian agriculture over the last 50 years.
- A comparison between agricultural values, ordinary rents and the current taxable base for farmland income has highlighted how it is undeniable that the system of taxation of land income on a cadastral basis leads to a significant erosion of the taxable base for both direct and indirect taxes in agriculture.
- Even if one were to opt for a taxation system that is not personal and progressive but real and proportional, the schemes and valuation techniques of the 1939 land cadastre are certainly not reproducible.

Overall, there is a clear mismatch between property taxation and business income taxation, which makes the distinction between farmland and agrarian income anachronistic. The results confirm previous evidence (Abbozzo, 1984; Lechi, 1993; Lechi and Segale, 1998; Guerrieri, 2003) and highlight that agricultural production is carried out by less than one-quarter of the farms surveyed by ISTAT and that the tax system is detached from this reality.

Therefore, the limitations of the cadastral system should lead to its abandonment as an instrument for defining ordinary average incomes as a tax base for direct taxes (Ribaud, 1995; Schifani, 1985). However, the land cadastre could maintain its civil functions by guaranteeing historical cadastral continuity and the subjective and objective variations indispensable for ascertaining property rights (Agosta et al., 2022). Similarly, it could retain the function of determining conventional

and/or cadastral reference values as a tax base for indirect taxes, similar to what has been done in other European countries (e.g., Austria).

5.1. Recommendations and pending questions

To achieve such a reform of the Italian cadastral system, the Italian Revenue Agency should concentrate its human resources and expertise on the following steps:

- Review and update crop qualities with a considerable simplification of the cartographic representation for the cadastral base;
- Create a cadastral map and census of territories characterised by conditions of economic marginality and affected by environmental constraints, where the priorities of land protection and conservation should reduce the taxable land value;
- Set up a ‘Land Value Survey Agency’ that can provide a public database of agricultural land property values, which would fill a crucial gap in the valuation activities of both public and private entities; and
- Implement a system of ‘conventional cadastral values’ to be used as a tax base for indirect taxes on transfers, inheritances and other land taxes that currently use cadastral incomes as a tax base.

The use and implementation of the information already existing in the databases (such as land values and rents and agricultural values), together with the experience and data held by the Italian Revenue Agency, could be instrumental in achieving such an objective.

In contrast, owing to political pressure from agricultural stakeholders, the recent enabling act on tax reform²¹ does not seem to address these issues. In addition, any attempt to reform the status quo could face strong resistance, such as in the case of the recent protest by farmers, unless an inclusive and shared process of redesigning taxation in this sector is promoted. Consequently, the cadastral system still represents an instrument for the real tax measurement of agrarian income and provides for generic changes in the determination of agrarian income, even though it is no longer able to provide any reliable measure of business income. In this regard, it is worth considering the provisions of the Legislative Decree 192/2024 (clarified by the Revenue Agency in Circular 12/E of 8 August 2025), which extended taxation based on agricultural income to more advanced cultivation systems (such as the production of vegetables in vertical farms as well as hydroponic crops), as they are considered related to agricultural activities.

²¹ Law No. 111/2023, Art. 5.

Unsurprisingly, the decision to keep the criteria for determining the tax bases of the agricultural sector unchanged, without adapting them to the structural changes that agriculture has undergone over the last 70 years, has generated a tax system contradicting constitutional objectives related to general taxation. At the extreme, given the total tax revenue from direct taxes and the IMU currently derived from agricultural taxation, one might even consider a complete abolition of direct taxation in agriculture.

However, over several decades, various actors have proposed the definitive abandonment of agricultural values and rents and their replacement with a real property taxation system with its tax base anchored to market value. Another proposal is the definitive abandonment of agrarian income in the determination of agricultural business income and its replacement with a personal budget-type taxation system. However, although income based on balance sheets should theoretically be used, the lack of an effective and cost-efficient control system, even in other economic sectors, has led to the use of flat-rate taxation methods and synthetic income indicators developed to facilitate control by authorities. In any case, the taxation of land income must be distinguished from the taxation of income from agricultural activities, as these two types of income are clearly distinct.

With respect to the taxation of land income, the shift to a cadastre of values would make it possible to define simplified taxation systems based on equalised values in relation to the rate of return on land capital. Despite the extreme fragmentation of Italian agriculture, the liberalisation of agricultural land rents since 2001 and the traceability of means of payment in land purchases and sales since 2006 have contributed to the emergence of widespread exchange prices.

These considerations do not provide immediate justification for the increase in taxation and/or a transition towards a taxation of actual income: in fact, the tax system responds not only to revenue objectives, but also to economic policy choices aimed at supporting particular sectors of economic activity, especially for small businesses operating in disadvantaged areas. In an asset-oriented tax system, the equalisation of the taxation of land income could be achieved with a single tax for all taxpayers (through appropriate levels of exemption or reduction in relation to marginality conditions and territorial constraints) and a deductible tax only for agricultural enterprises that use real estate as a capital asset and opt for balance sheet taxation. To determine incomes, one could consider forms of balance sheet taxation for businesses with turnovers and asset values above a certain threshold while allowing simplified forms of taxa-

tion for other agricultural entrepreneurs (with certain taxable income rates in relation to the turnover of agricultural activities, as is already the case for related agricultural activities). Like the 'flat-rate or minimum tax regime' (known in Italy as '*regime forfetario*') for professionals, artisans and traders that has been implemented since 2015, this type of regime may be introduced with differentiated turnover thresholds for agricultural entrepreneurs. However, some doubts remain which would require further research and evaluations, such as: would such a regime be really applied in the agricultural sector? If yes, with what consequences? And, also, would it be enforceable by the public body responsible for monitoring and assessing taxable income?

Overall, any attempt to reform and enhance the current taxation systems for agricultural incomes should certainly consider the high level of diversity of Italian agriculture, where some farms generate high incomes, whereas others would likely be overwhelmed by increased tax burdens. Therefore, some relevant issues deserve attention, such as the eligibility requirements for an income tax based on balance sheets or updated conditions for those who could benefit from tax exemptions and concessions in the agricultural sector. It follows that policymakers, public authorities and administrations should rigorously address the fundamental issue related to the identification of those to be considered and defined as "farmers for tax purposes". Additionally, given that the agricultural sector traditionally receives substantial public funding from the CAP, which in many internal and low-productivity areas represents a large share of farm income, policymakers and public authorities could consider whether it is more reasonable for taxpayers or society to invest additional resources (and transition costs) in developing a more efficient and effective agricultural taxation system rather than simply managing a reduction in income support levels. Also, at the current status, authorities and stakeholders could evaluate whether and how income support measures should be included in the taxable income, considering what are the implications of including/excluding them. Likewise, some key issues questions should finally arise around actions for a better targeting of both taxation and income support measures (namely, 'what are the farmers still needing income support?', and 'should a single taxation method be adopted for all farmers?').

However, considering some major caveats is necessary, mainly because all the analyses conducted largely relied on aggregate and secondary data, which are not able to capture the wide heterogeneity traditionally characterising the agricultural sector in Italy. Moreover, such investigations will need to be updated in the com-

ing years, as they rely on data that are certainly not time invariant. Thus, future studies could extend the time span and adopt a territorial or specialisation approach (based on administrative regions, altimetric zones, type of farming, etc.) when performing the analyses to overcome the limitations of the current research.

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Exploratory data analysis to support the second SNAI programming cycle

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Abstract. In 2012, the Italian “National Strategy for Inner Areas” (SNAI) was approved to enhance essential services (transport, education, healthcare) and boost economic growth in underdeveloped areas. After more than ten years since the first SNAI programming cycle (2014-2020) and at the beginning of the second one (2021-2027), this research analyses the thematic scopes and funding of projects implemented during the first SNAI cycle to support local authorities in the second cycle. The analysis focuses on the four Inner Areas of Piedmont to support the SNAI strategy development process in Valsesia, which was designated as one of the new Piedmont Inner Areas in 2022. The study, part of the B4R - Branding4Resilience project, uses government open data and Exploratory Data Analysis to examine the geographic and thematic distribution of SNAI interventions. Results show the allocation of projects and public funds, identifying popular themes and gaps. Among the most significant findings, the thematic scopes of “Transport and Mobility” and “Social Inclusion and Health” emerged as the most funded, while scopes such as “Environment”, “Research and Innovation” and “Employment and work” were significantly underrepresented, especially in Piedmont. Understanding the strengths and weaknesses of the first cycle is crucial for refining future strategies, avoiding past inefficiencies, and maximising the impact of upcoming interventions. Insights drawn from the analyses aim to support local authorities in addressing new interventions and actions, enhancing strategic planning for territorial projects.

Keywords: Inner Areas cohesion policy, SNAI strategies development, economic rural development.

JEL codes: R53, R58, R11, H5.

1. INTRODUCTION

Italy (and, to some extent, Europe) is a polycentric territory, with a dense network of urban, rural and smaller centers, often characterized by the weakness of the services offered and the socio-economic conditions of the population. The study of this fragility, which began in the 1980s (Dematteis et al.,

1983), focused on both the marginalization and isolation of territories and the degradation of the natural and cultural heritage, leading to the identification of inland areas as dependent on physical factors and/or political processes that did not take account of the potential of the territories to promote local development.

The marginalization and depopulation of these areas are the result of a complex, stratified process that has taken place over the last century. Socio-economic phenomena such as the progressive aging of the population, the decline of local economies and the reorganization of formal territorial aspects have increased these challenges since the end of the Second World War (Coordinamento rete nazionale giovani ricercatori per le aree interne, 2021).

In addition, these areas are characterized by limited accessibility, especially when compared to urban centers (Küpper et al., 2018; Moseley, 2023), and by disparities in terms of equity and social inclusion (Farrington and Farrington, 2005); despite their critical situation, inner cities have a lot of unexpressed potential (NUVV - Nucleo Valutazione e Verifica Investimenti Pubblici, 2020). These areas are characterized by the presence of environmental and cultural resources, with a strong commitment to product quality and environmentally sustainable production methods. Public administrations in these areas must also ensure active citizen participation, which fosters a strong sense of community (NUVV - Nucleo Valutazione e Verifica Investimenti Pubblici, 2020).

At present, the term ‘Inner Areas’ encompasses two key dimensions. Firstly, it refers to areas that are far from major urban centers, globalized networks, dynamic population trends and the widespread connectivity that characterizes the contemporary world - in other words, these areas exist outside the dominant development model (Pasqui, 2021). Secondly, it evokes a sense of ‘intimacy’ and ‘inwardness’, referring to places, landscapes and heritage that evoke a different time and space and offer alternative ways of living (Coordinamento rete nazionale giovani ricercatori per le aree interne, 2021). The stark contrast between urban centers and Inner Areas has led to disparities in terms of equity and social inclusion, affecting both the public and private economic sectors. For these reasons, Inner Areas have been supported by specific territorial policies (Caruso et al., 2021), which also serve as ideal laboratories for developing innovative territorial models and experimenting with interventions to address societal demands/needs that don’t find satisfaction in the traditional welfare system (NUVV - Nucleo Valutazione e Verifica Investimenti Pubblici, 2020). To address these issues, the European Spatial Development Perspective (ESDP) has ushered

in a new era of policies, adopting a regional perspective and seeking to promote polycentrism (Barca et al., 2014a; Caruso et al., 2021; Farrington and Farrington, 2005; Moseley, 2023).

In the Italian context, an important milestone was reached in 2012 when the Minister for Economic Development approved the “National Strategy for Inner Areas” (SNAI), defined for the first time in the National Reform Programme (NRP) of the 2014-2020 Partnership Agreement (Lucatelli et al., 2014). The main objective of this strategic territorial initiative was to redress the imbalance in essential local services in 72 selected Inner Areas (Lucatelli, 2015) by improving public transport, education, social welfare and health care. At the same time, it aimed to stimulate economic growth and enrich the natural and cultural heritage of these regions. The overall long-term goal of SNAI was to reverse the trend of depopulation and ensure the vitality of these areas. A second important milestone was then reached in 2022, when 56 new Inner Areas were selected and admitted to the SNAI co-founding 2021-2027, including 43 areas and 13 coalitions - qualified as Inner Areas - supported by non-national funding (Servizio studi Camera dei deputati XIX Legislatura, 2023).

After more than ten years since the first SNAI programming cycle (2014-2020) and at the beginning of the second one (2021-2027), some Exploratory Data Analyses (EDA) on specific aspects of the first cycle implementation could support local authorities in addressing new strategies and actions to be proposed for the second cycle.

Therefore, the aim of this research is to analyze the thematic scope and the amount of public funding of the projects implemented during the first SNAI programming cycle and to highlight the main results at the national and regional levels. In addition, a more in-depth analysis is carried out at the regional level, focusing the attention on Piedmont Region, where the Valsesia territory was recently designated as new Inner Area and the SNAI strategy definition process is currently ongoing. This paper explores the hypothesis that the Valsesia new Inner Area could exploit the lessons learned from the four previous Piedmont Inner Areas to improve its strategic planning in the SNAI framework. This study was developed in the context of a collaboration between the Politecnico di Torino and the Valsesia Mountain Union, activated since 2020, in the context of the B4R - Branding4Resilience research project of national interest (PRIN 2017) (Ferretti et al., 2022; Malavasi et al., 2023; Rolando et al., 2024; Torriani et al., 2023). The following research questions guided the data analyses carried out in this paper: *i*) How should the new Inner Areas address their strategies in relation

to the project thematic areas to be considered? *ii*) How much funding was allocated to each project? Two additional questions helped shape the direction of future research: *iii*) Which uncovered sectors should be prioritized for the fund allocation? *iv*) What design strategies could be selected (or excluded) in the upcoming cycle?

The results provided an in-depth analysis of the projects implemented in each of Italy's Inner Areas during the first SNAI programming cycle (2014-2020), exploring how each area has managed and implemented its unique strategy. Specifically, in the context of the Piedmont Inner Areas, the research outlined both the strengths and the strategic shortcomings of the areas, providing valuable insights into the diversification and innovation of strategic planning that can support the Valsesia local authorities in their future programming.

The paper is structured as follows: Section 2 presents the literature background, with a bibliographic review and research on the implementation of SNAI in Italy. Section 3 presents the methodological approach adopted, while section 4 explains the data collection and sampling process. Section 5 discusses the results at both national and regional level, and section 6 provides concluding remarks.

2. BACKGROUND

2.1. The 2014-2020 SNAI programming cycle

Based on the principles of the European Cohesion Policy, SNAI has created its own geography of Italy's internal areas, drawing up a new map of the territories and classifying them according to rules never before considered (Barca et al., 2014b). In addition to the main objectives of redressing the imbalance in essential local services, SNAI also defines some "minor" objectives: *i*) increasing the well-being of the local population and the local demand for labour and employment; *ii*) making better use of territorial capital; *iii*) reducing the costs of hydrogeological instability, the degradation of historical and architectural capital and the destruction of nature; *iv*) strengthening development and quality of life factors (NUVV - Nucleo Valutazione e Verifica Investimenti Pubblici, 2020).

The first selection process (started in 2012) was based on the proximity to the main service centers: the prevailing criteria were based on the distance of each municipality from essential services and the difficulty of reaching the so-called "poles", where the following essential services are guaranteed: a secondary school, a hospital with a first level of Department of Emergency Urgency and Acceptance (DEA); a railway station of at

least silver type (stations with medium/small systems, equipped only with regional/metropolitan services). The distance was calculated using an accessibility indicator, which measures the travel time to the nearest Pole.

These poles are generally urban centers with a full range of services such as schools, hospitals and railway stations (Barca et al., 2014b). Based on their distance from these poles, areas were categorized into four different types: Belt Areas (within 20 minutes), Intermediate Areas (up to 40 minutes away), Peripheral Areas (up to 75 minutes away) and Ultra Peripheral Areas (more than 75 minutes away from a pole).

The 2014-2020 SNAI programming cycle identified 72 internal areas, which are fairly homogeneous throughout Italy, covering a large part of the Italian territory, slightly less than 60% of the national territory, involving almost 52% of Italian municipalities (4181) and inhabited by 22% of the Italian population. The orography of the territory and the demographic size of the municipalities are indicators of fragility, with a risk of depopulation, low presence of essential services and weak territorial management (Strategia Nazionale delle Aree Interne, 2020). This ubiquitous presence of these Inner Areas underlines their importance as key elements of the Italian territory, which must be fully included in all public policy considerations, rather than being relegated to the status of 'special cases'. It is unrealistic to assume that one-size-fits-all national policies can effectively address the diverse needs of the entire territory. Therefore, in formulating these policies, due consideration must be given to the unique characteristics and needs of all regions of the country. Furthermore, 59% of these agglomerations have fewer than 2,000 inhabitants and 25% have between 2,000 and 5,000 inhabitants (Strategia Nazionale delle Aree Interne, 2020). The total amount of funding was 1,167 million euros, co-financed by Laws n. 147/2013, n. 190/2014, n. 208/2015, n. 205/2017 and by EU funding programs such as the European Regional Development Fund (ERDF), the European Social Fund (ESF), the European Agricultural Fund for Rural Development (EAFRD) and the European Maritime and Fisheries Fund (EMFF).

In 2020, the SNAI programming cycle was strengthened and expanded with the identification of 43 new Inner Areas and new funds, which amounted to 172 million euros for the 2021-2027 years. The approval process of new Inner Areas was concluded with the CTAI (Inner Areas Technical Committee) of 29 September 2022; therefore, several local authorities are currently managing complex processes to identify their local strategies and the related activities to be funded, even if they cannot totally learn from the results of the first SNAI pro-

gramming cycle (2014-2020), which outcomes are not fully known. This lack of knowledge can be overcome by critically analyzing the information at national scale, which describe the projects and the investments implemented in the past SNAI programming cycle that are still in the development phase.

Moreover, in 2020 the Marginal Municipalities Fund (Fondo Comuni Marginali) consolidates resources from two key provisions: the DPCM of September 24, 2020, which allocated funds to support economic, artisanal, and commercial activities in Inner Areas from 2020 to 2022, and the DPCM of September 30, 2021, which aimed to provide assistance to disadvantaged municipalities from 2021 to 2023. Following the dissolution of the Agency for Territorial Cohesion (DPCM 22 marzo 2024 - Soppressione dell'Agenzia per la coesione territoriale e trasferimento delle relative funzioni al Dipartimento per le politiche di coesione della Presidenza del Consiglio dei ministri), the responsibility for processing disbursement requests and transferring funds was assigned to the Department for Cohesion Policies and the South. According to Article 15 of Decree-Law No. 60 of May 7, 2024, these funds will not be revoked if utilized by December 31, 2025, where 'utilization' is defined as the formal identification of beneficiaries through a municipal resolution. Municipalities must follow specific procedures for requesting funds for the second and third annual installments, ensuring compliance with monitoring and reporting requirements.

2.2. The current debate around the SNAI implementation

Over the last 10 years, during the implementation of the first programming cycle, the national debate on SNAI and the international one on similar programs has been very active (Barca and Carrosio, 2020; Carrosio, 2019; Cotella et al., 2021; Cotella and Vitale Brovarone, 2020; Fenu and Giaccaria, 2023; Rolando et al., 2022; Scrofani and Accordino, 2023; Torriani et al., 2023), also highlighting positions of partial distance from the SNAI policy (Moscarelli, 2021; Rossitti et al., 2021; Sargolini M., 2016; Vendemmia, 2021; Vendemmia et al., 2022) and some interesting case studies (Andreoli and Silvestri, 2017; Carrosio, 2016; Pappalardo and Saija, 2020; Urso, 2016).

While Rossitti et al. (Rossitti et al., 2021) raised questions about the grid of indicators for the evaluation and selection of Inner Areas, Moscarelli (Moscarelli, 2021) proposed a thought-provoking analysis that offers insights into the critical assessment of this policy. First, it questions the methodology used to categorize municipalities as 'poles' or 'centers', with the provision of essential services determining their classification. The use of

spatial and geographical distance alone, with a cut-off point of 20 minutes, to classify areas as 'inner' raises questions about the validity and inclusiveness of this approach. Secondly, the author analyzes territorial marginality: he observes that while the SNAI map only identifies degrees of peripherality based on the proximity of services, it overlooks a comprehensive understanding of marginality. Therefore, the direct link between inner space and true marginality is not entirely correct. The binary classification system proposed by SNAI divides Italy into two clear categories: municipalities that have services and are attractive, and municipalities that lack both. Finally, Moscarelli questions the political relationship between SNAI and the number of other parallel policies and actions that operate in the same areas.

However, the creation of a specific policy for peripheral areas has brought these areas into the public, cultural and academic debate (Carrosio, 2018; Dezio, 2021; Rolando et al., 2023). Refining the categorisation of Inner Areas based only on geographical location and proximity to urban centers oversimplifies the complexity of the categorisation. These factors, although important, are only two of those that describe the complex of marginalization of a territory (such as inner cities or regions in economic decline). Recent studies have offered an interpretation of marginality that goes beyond the structure based on geography and center-periphery dynamics (Vendemmia, 2021), defining it as a lack of socio-economic and political relations (Bock, 2016; Leimgruber, 2018; Pelc, 2006; Pessina, 2021).

In this new perspective, it is essential to also analyze the (social) services of citizenship in order to understand the reasons for the marginality of these territories and what are the useful tools for developing place-sensitive strategies for their redevelopment (Vendemmia et al., 2021). Given that the objective of the strategy is to guarantee the level of essential services throughout the territory, it is not specified why the three main criteria used to define the internal areas (accessibility, health and education) are identified as essential (Vendemmia et al., 2021). In 2018, the Foundational Economy Collective gave a definition of "goods and services [...] essential for the well-being of users", which are those goods and services whose "limited access hinders life and limits its possibilities" (Vendemmia, 2021). These goods and services fall into three categories: *i*) the basic material economy (transport of goods and people, but also electricity, water and gas, internet access, accessibility, banking and postal services and, finally, the sale of cars); *ii*) the basic providential economy (universal services such as health, education, public order and public administration); *iii*) the neglected economy: activities that provide goods and

services that are “perceived as essential” (Vendemmia, 2021). This category includes “ordinary and culturally embedded needs” that evolve according to socio-cultural parameters (Moretto, 2021).

Despite these findings, the SNAI is widely credited with focusing on territorial governance processes on disadvantaged areas and proposing a structural approach. The three primary services mentioned above are not sufficient to provide a comprehensive picture of the characteristics of the territories or to highlight their problems.

Thus, with the aim of studying methodologies to define appropriate solutions for marginal areas, some research has been carried out to propose the most appropriate solutions, experimenting analytical methods based on clustering algorithms to identify the prevailing problems, as in the case of the Inner Areas of Puglia (Marucci et al., 2020), others have taken into account the socio-economic characteristics of the inhabitants (Vendemmia, 2021), or others have analyzed criteria related to the presence of hydrogeological fragility or, more generally, environmental risks (Pessina, 2021).

Other researchers have focused on local behaviours, making the inhabitants the subjects who define their essential needs and the time thresholds for achieving them. In this case, the tools used are: focus groups, parallel tables, interviews, participatory surveys with the aim of creating “cognitive supply chains” (Golino and Marchetti, 2017) otherwise actions that combine local development with services based on experience and know-how rooted in the territory (Lucatelli, 2016).

The complexity of Inner Areas requires a dual approach: the use of analytical tools and the application of bottom-up methods involving active listening to the inhabitants. This combination of quantitative and qualitative research methods makes it possible to obtain a more complete analysis of this multifaceted phenom-

enon (Gaber and Gaber, 1997) and, at the same time, to identify the specific needs of the inhabitants of each area and the essential services they require (Vendemmia et al., 2021).

For these reasons, the quantitative exploratory analyses carried out in Section 5 can certainly provide useful indications on the implementation of the first SNAI programming cycle and thus support local authorities to address and strengthen the local strategy for the next programming cycle.

3. METHODOLOGICAL APPROACH

The research hypothesis underlying this study is that the adoption of a shared yet adaptable approach – avoiding rigid and pre-defined processes – is crucial to support Public Authorities in designing effective and context-sensitive territorial strategies for Inner Areas. Building on this assumption, a structured, multi-phase methodological approach was developed, encompassing clear goal definition, rigorous data preparation, and contextualised analysis. It was based on 4 subsequent phases, which used the output of the previous one as input for the following. Each phase includes different sub-phases, which are represented in Figure 1: Goal definition (1), Data collection and preparation (2), Data analysis (3) and Results interpretation (4).

In the first phase (Goal definition) it is fundamental to address the context of the research and identify the research questions to outline the main objective of the study. In the second phase (Data collection and preparation), materials and data sources are identified, collected, harmonized, and managed in databases. In this phase, different steps of refinement allow to check data and correct errors, to build the final database used for

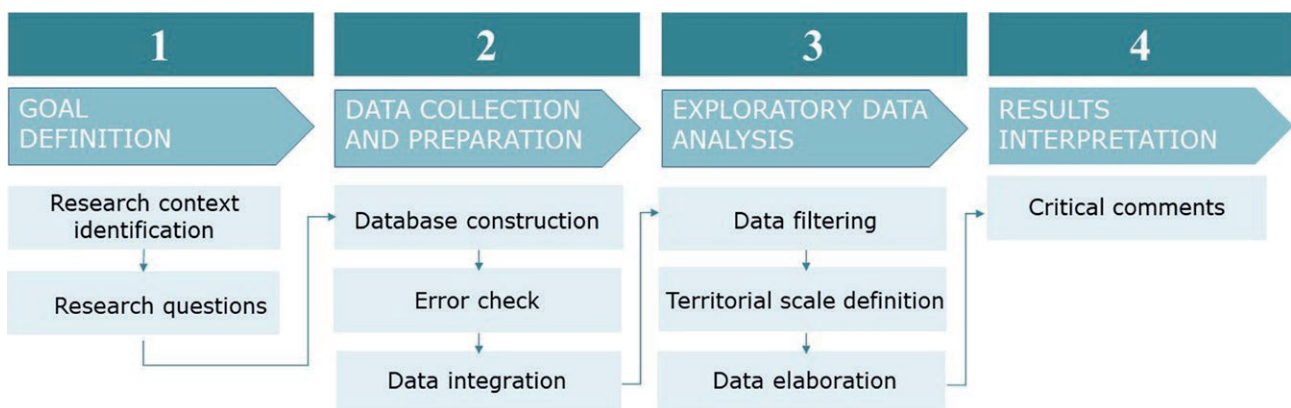


Figure 1. The 4-phase methodological approach (Source: Authors' elaboration).

the subsequent analyses. In the third phase (Data analysis), information and data are filtered and selected to build dedicated data samples to be analyzed. The data filtering sub-steps and selection process can be used at different territorial scales. The outputs and the results of this phase can be interpreted in the final step. During the fourth and final phase (Results interpretation) some critical comments and possible research developments are outlined. This phase can support Public Authorities to define efficient and effective territorial strategies or actions for inner territories.

4. CASE STUDY AND DATA SAMPLING

The first SNAI programming cycle (2014-2020) and its designated 72 Inner Areas represent the case study of this research. The 72 Inner Areas are located rather homogeneously through Italy: 21 areas are in South Italy, 28 in the Center and 23 in the North.

Figure 2 shows the nationwide selected 72 Inner Areas of the first SNAI programming cycle, classified into Belt areas, Intermediate Areas, Peripheral Areas and Ultra Peripheral (NUVV - Nucleo Valutazione e Verifica Investimenti Pubblici, 2020).

The 72 Inner Areas presented 2,258 projects, amounting to a total funding of 1,167 million euros, divided into:

- 266 million euros (from the resources allocated by Laws n. 147/2013, n. 190/2014, n. 208/2015 and n. 205/2017);
- 712 million euros (from the resources allocated by ERDF, ESF, EAFRD and EMFF EU funding programs);
- 132 million euros (from other public resources);
- 57 million euros (from private resources).

Therefore, to analyze the projects funded during the first SNAI programming cycle, a data sample was built by collecting data from three open data sources: the Department for Cohesion Policies and the South (formerly the Agency for Territorial Cohesion - SNAI section), OpenCoesione portal and the National Institute of Statistics (ISTAT).

From the website of the Department for Cohesion Policies and the South (formerly the Agency for Territorial Cohesion -SNAI section <https://www.agenziaco-esione.gov.it/strategia-nazionale-aree-interne/>), it is possible to download data related to selection processes, planning strategies, and subsequent formalization of the SNAI strategy. Specifically, the available resources include: the annual report on Inner Areas (Strategia Nazionale delle Aree Interne, 2020), the official Map of Inner Areas, the List of Municipalities for each Inner

Area, and the Guide to “Open Diagnosis”. These documents were used to analyze and compare the characteristics of different Inner Areas. When available, the following documents provided further detail: Approved Area Strategy Framework (summary), Framework Program Agreement, Approval documents, and Monitoring report. In particular, the “Open Kit” indicators served as the starting point to select the indicators identified in this research (Comitato Tecnico Aree Interne, 2020). These OpenKit indicators, published within the SISTAN network, are accompanied by essential metadata (including definition, calculation method, unit of measurement, reference period, and sources), and are periodically updated in line with each release of foundational data from official statistics (Nucleo di valutazione e analisi per la programmazione., 2023). The Open kit indicators can be organized into nine thematic categories:

1. Main characteristics: number of municipalities, population, surface area, ratio between the resident population and the territorial surface;
2. Demography: percentage of the resident population divided into age groups, population variation over the years;
3. Agriculture and sectoral specialization: utilized agricultural area and its variation over the years, ratio of people working in the sector, number of businesses active in the area;
4. Digital divide: population reached by ADSL and ultra-broadband;
5. Cultural heritage and tourism: number of state and non-state cultural places, number of visitors and accommodation rate;
6. Health: hospitalization rate, arrival time of first aid vehicles on site;
7. Accessibility: distance from the nearest pole, offer of the local public transport service, accessibility to the nearest railway station and intensity of railway and airport services;
8. School: number of schools, percentage of municipalities with primary schools and average number of pupils;
9. Associations between municipalities: number of municipalities in union and in agreement.

The second data source selected was the OpenCoesione portal (www.opencoesione.gov.it), which is an open government initiative on cohesion policies in Italy and promotes a widespread civic participation monitoring the effectiveness of interventions with the publication of data on funded projects. The open dataset contains all the information related to each reference project. The dataset (updated date: 30 June 2022) contains around 1700 projects described by 203 variables; among the

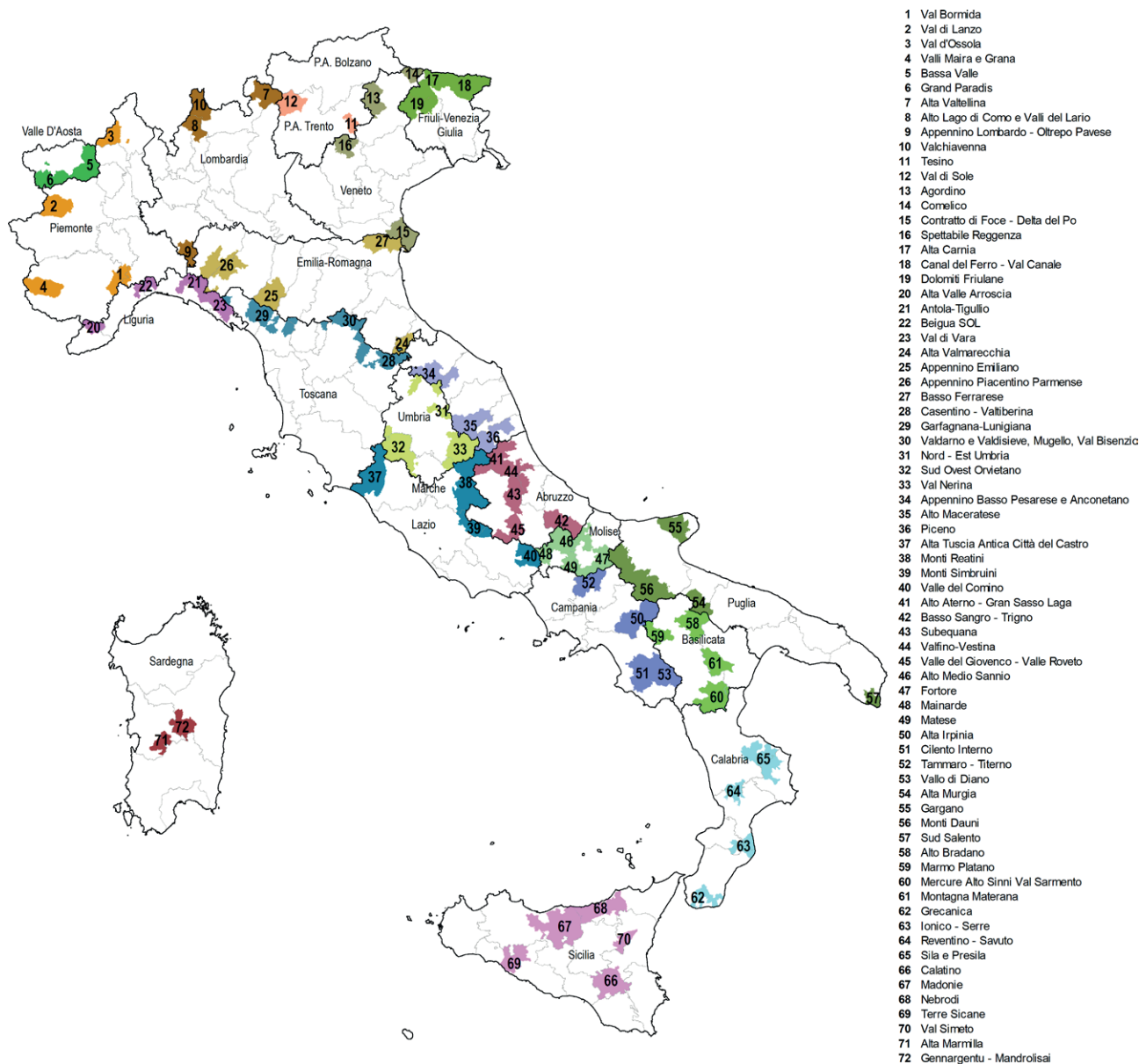


Figure 2. Inner Areas selected by the first SNAI's programming cycle (Source: Strategia Nazionale delle Aree Interne, 2020).

most important are: conformation of each Inner Area (region, province, municipalities belonging to the areas); the eleven synthetic sectors used to catalogue the projects; a brief description of each project; funds divided by type (private, public, regional, province, municipality, European Union, etc.); composition of public funds (ERDF, ESF, EAFRD and EMFF); the progress of each project and the amount of its funds. Subsequent analyses do not incorporate the latest graphs and data, last updated on October 31, 2022, and subsequently uploaded to the website in February 2023. These recent updates were

omitted, potentially impacting the comprehensiveness and accuracy of the subsequent analyses conducted.

Lastly, the National Institute of Statistics (ISTAT - <https://www.istat.it/>) provides data at the national, regional, provincial, and municipal levels and performs official statistics to support citizens and decision-makers. For this research, the portal was used to integrate the missing data (at the municipal scale) in the previous mentioned portals. In detail, the consistent joined data are the building density, the number of inhabitants, the altitude and the per capita income (updated date: 1 January 2022).

The final database developed for this research analysis comprises 2258 projects detailed by 203 variables (Table 1). As all data were sourced from official channels, potential compilation errors have not been considered in this initial phase of analysis. Nevertheless, some inconsistencies within the open data datasets were identified and the data structure was improved. Specifically, the database was checked and structured in 3 Geographic areas joining all Italian Regions: North Italy (Valle d'Aosta, Piedmont, Liguria, Lombardy, Trentino-Alto Adige, Veneto and Friuli-Venezia Giulia); Centre Italy (Emilia-Romagna, Tuscany, Marche, Lazio, Umbria, Molise, Abruzzo and Sardinia) and South Italy (Basilicata, Calabria, Campania, Puglia and Sicily). In each Italian Region there is a different number of Inner Areas: 2 in Trentino-Alto Adige, Valle d'Aosta and Sardinia; 3 in Friuli-Venezia Giulia, Marche, Tuscany and Umbria; 4 in Basilicata, Calabria, Campania, Emilia-Romagna, Lazio, Liguria, Lombardia, Molise, Piemonte, Puglia and Veneto); 5 in Abruzzo and Sicily.

Furthermore, some data implementations were necessary and through the Department for Cohesion Policies and the South (former Agency for Territorial Cohesion -SNAI section) some missing projects were collected on the basis of the comparison of the "Framework Program Agreement" of each Inner Area. Table 1 shows the metadata of the main variables of the dataset.

5. RESULTS

The entire data sample was analyzed by using Exploratory Data Analysis (EDA), an investigative process that employs summary statistics and graphical tools to examine and interpret various variables: total public funds, private funds, number of projects, prevalent sectors, project status, geographical area, and Inner Area average altitude. In the following subsections data analysis results highlight the projects' thematic scopes and funds at the national and regional levels (section 5.1) and in the 4 Piedmont Inner Areas (section 5.2), outlining some possible scopes to be considered in the context of the current second SNAI programming cycle (section 5.3).

5.1. Projects' thematic scopes and funds at the national and regional levels

The whole data sample consisting of the 2258 projects referred to the 72 Inner Areas was analyzed to study the first SNAI programming cycle (2014/2020), in terms of geographical and thematic distribution of the

projects, allocation of funding and progress of implementation. The geographical division in the different Italian Regions was assumed to make some comparisons on the distribution and allocation of funds because Italy presents territories with quite different economies, urban and administrative development.

The projects were clustered according to the 11 thematic scopes, defined by OpenCoesione on the basis of: EU priority themes and EU fields of intervention associated with the individual projects co-financed respectively in the two programming cycles 2007-2013 and 2014-2020; sectoral classifications of the Project Unique Code (CUP). (<https://opencoesione.gov.it/it/faq/#!comevengono-classificati-i-progetti-nei-temi-sintetici-di-open-cohesion>). By considering its specific goals, each project was related to a specific thematic scope (Table 2).

Firstly, the total number of projects was analyzed for each thematic scope and related to the projects' status and to the received public funds (Figure 3). Results show that the amount of funds received is not directly proportional to the number of projects. For example, the funds related to "Transport and Mobility" were around 80 million euros but with a limited number of projects (149); on the contrary, there were many projects related to the thematic scope "Competitiveness of companies" (559), even if corresponding to less than 20 million euro of funds. Few funds (less than 10 million) were allocated to projects related to the thematic scopes "Environment", "Employment and work" and "Administrative capacity", while a great amount of funds (between 50 and 80 million euros) were allocated to projects related to "Transport and mobility", "Culture and tourism" and "Social inclusion and health".

After an overall analysis of projects and funds at the national level, the data analysis was focused on the number of projects for each thematic scope in each Italian Region. Hence, a comparative table (Table 3) was developed to outline all 72 Inner Areas selected by the first SNAI programming cycle (rows) and the related allocation of projects across the 11 thematic scopes (columns). Table 3 highlights the total number of projects funded in each Inner Area, the thematic scopes that many projects have focused on (green cells), those that have received less attention (yellow cells), and those for which no projects have been proposed (red cells).

Firstly, the results show that at the national level, the thematic scopes with fewer focused projects were 'Research and Innovation', 'Employment and Work', 'Digital Networks and Services', and 'Environment', while those with a higher concentration of projects were 'Transport and Mobility', 'Social Inclusion and Health', and 'Education and Training'.

Table 1. Metadata of the main variables of the dataset (Source: Authors' elaboration).

Data structure		Data content	Data value		Data source
Field name			Vocabulary	Field type	
<i>Inner Areas variables</i>					
Inner Area name	Name of the Inner Area		open	Text	OpenCoesione data
Number of Municipalities	number of municipalities forming part of the Inner Area		open	Number	OpenCoesione data
Inner Area size	It is the total area of a portion of territory		open	Number in km ²	OpenCoesione data
Number of inhabitants of the entire Inner Area	Number of inhabitants of each Inner Area (sum of inhabitants of all the municipalities)		open	Number	OpenCoesione data
Density per inhabitant	number of people living in a specific area		open	Number in inhab./km ²	OpenCoesione data
Italian Geographical Areas	Geographic location of each Inner Area		closed	Text: North, Centre, South	Authors' elaboration on OpenCoesione data
Total funds in the Inner Area	Public (FESR, FSE, FEASR e FEAMP) and private funds		open	Number in Euros	Authors' elaboration on OpenCoesione data
Average altitude	Average altitude of all municipalities of each Inner Area		open	Number in Meters (above sea level)	Authors' elaboration on ISTAT data
Building density	Relationship between density and built morphology		open	Number in Building / m ²	ISTAT data
Number of Inhabitants in the Inner Area	Total number of inhabitants (sum of inhabitants in each municipality)		open	Number	ISTAT data
Per capita ratio	Amount of gross national product per capita in a certain period of time		open	Number in €/ inhabitants	ISTAT data
<i>Projects variables</i>					
Project title/name	project title reported in the SNAI local strategy report		open	Text	Department for Cohesion Policies and the South (SNAI section)
Project description	concise description of the project, where the purposes, the objective, and the location are explained		open	Text	Department for Cohesion Policies and the South (SNAI section)
Projects' thematic scope	Project classification (and research) themes: aggregation of sectors and fields of intervention		closed	Text: Environment, Administrative capacity, Competitiveness of companies, Culture and tourism, Energy, Social inclusion and health, Education and training, Employment and work, Digital networks and services, Research and innovation, Transport and mobility.	OpenCoesione data
Project status	Work progress of the project		closed	Text: Completed, in progress, Settled, Not started	OpenCoesione data
Percentage of funds	Percentage of funds for the project's sector out of the total		open	Number	Authors' elaboration on OpenCoesione data
Percentage of number of projects	Percentage of number of projects for the project's sector out of the total		open	Number	Authors' elaboration on OpenCoesione data

Moreover, although each area presents specific characteristics closely tied to its territory, it emerges that certain thematic scopes still prevailed despite these local characteristics. From a geographi-

cal point of view, it emerges that in the Northern areas, the less common thematic scopes were "Environment", "Research and innovation", and "Employment and work", while the most frequent ones were

Table 2. Description of the 11 thematic scopes (Source: Authors' elaboration on OpenCoesione data).

Thematic scope	Goal of the projects
Environment	<ul style="list-style-type: none"> - distribution, collection and treatment of wastewater - waste management - risk prevention (defense works of inhabited centers, production sites and infrastructures), - prevention of coastal erosion and hydrogeological instability - slope consolidation - hydraulic cleaning actions - adaptation to climate change - promotion of biodiversity and nature protection
Administrative capacity	<ul style="list-style-type: none"> - public infrastructure to ensure public safety - institutional capacity building at national, regional and local level - improve the design of good policies and programs as well as their implementation, monitoring and evaluation - support activities for statistical production and technical assistance to administrations regarding the phases of the policy cycle (programming and implementation) - evaluations, studies and information and communication activities
Competitiveness of companies	<ul style="list-style-type: none"> - guarantee funds, funds for loans and access to credit - granting of co-guarantees and counter-guarantees through the credit guarantee system and venture capital funds - tools to support the entrepreneurial fabric through the creation of a new business - construction of new production plants or the expansion and modernization of existing production plants - improvement of the functionality of the production areas - program contracts to support investments promoted by large companies and the Integrated Benefit Packages (PIA)
Culture and tourism	<ul style="list-style-type: none"> - infrastructures for the protection and conservation of cultural heritage - interventions aimed at improving tourist services and at promoting and enhancing natural resources
Energy	<ul style="list-style-type: none"> - construction of plants for the production of energy from renewable sources - promotion of energy saving in productive sectors - actions for the development of diffused cogeneration (of electricity and heat) and trigeneration (of electricity, heat and cold) - diffusion of district heating and district cooling
Social inclusion and health	<ul style="list-style-type: none"> - improve the social inclusion of disadvantaged groups - investments in social and socio-health infrastructures - infrastructure for housing policies - infrastructure and health services - interventions to promote active and healthy aging and to promote active inclusion
Education and training	<ul style="list-style-type: none"> - promotion of school success and social inclusion in the fight against early school leaving - actions aimed at improving students' learning and enhancing excellence - interventions in favor of school staff (such as training) - adult education courses
Employment and work	<ul style="list-style-type: none"> - active and preventive measures on the labor market - development of lifelong learning systems and strategies in enterprises - design and disseminate more productive ways of organizing work and support for self-employment - improve access to employment - increase the sustainable participation and advancement of women - reconcile work and private life
Digital networks and services	<ul style="list-style-type: none"> - broadband and ultra-broadband infrastructure and connectivity, - services to citizens and businesses, and aid to businesses relating to new technologies - multimedia educational networks and laboratories in schools, e-government projects - e-health and e-inclusion services
Research and innovation	<ul style="list-style-type: none"> - business financing for industrial research and experimental development projects - research offer by universities and research centers - technology transfer to the business world and advanced business services for research and innovation
Transport and mobility	<ul style="list-style-type: none"> - strengthening of railway lines, of the road network, of port connections, of intermodality - sustainable mobility interventions and public transport in urban areas

“Social inclusion and health”, “Education and training”, “Transport and mobility”. In the Central areas, the less common thematic scopes were “Research and innovation”, “Digital networks and services”, and

“Employment and work”, while the most frequent ones were “Competitiveness of companies”, “Social inclusion and health”, “Education and training”. Lastly, in the Southern, the less common thematic scopes were

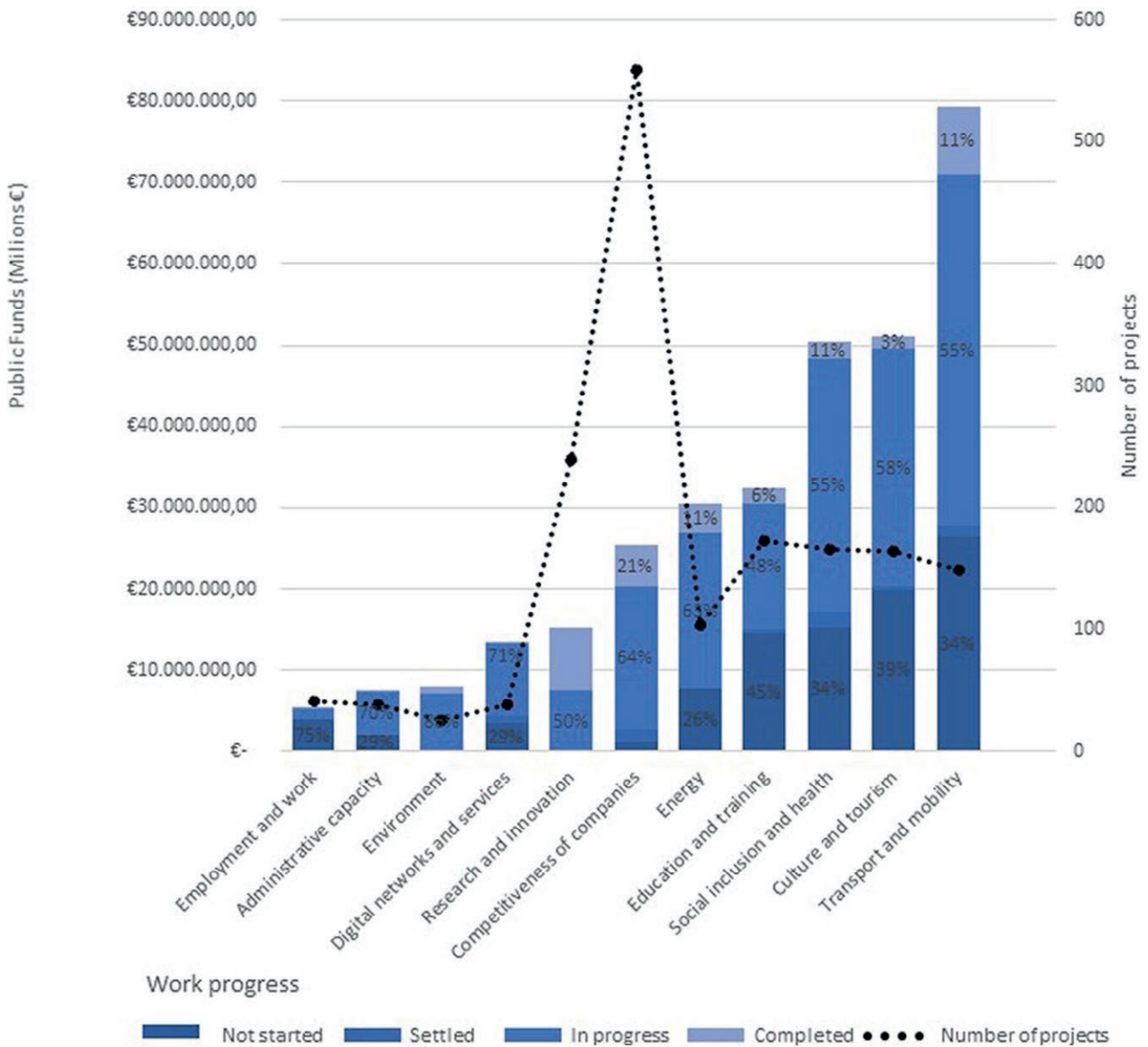


Figure 3. Public funds and the number of projects related to the 11 thematic scopes at the national level (Source: Authors’ elaboration on OpenCoesione data).

“Research and innovation”, “Employment and work”, and “Administrative capacity”, while “Transport and mobility” emerged as the prevailing one.

5.2. Projects’ thematic scopes and funds in the 4 Piedmont Inner Areas

Considering the results outlined at the national level, this research focused on the Piedmont region, specifically delving into its four Inner Areas, founded by the

first SNAI programming cycle: Val Bormida, Val di Lanzo, Valli Maira and Grana and Val d’Ossola.

Figure 4 shows that three of these areas (Valli Maira and Grana, Val di Lanzo and Val d’Ossola) are located at the national border and adjoin foreign territories (the first two border France while the third Switzerland); only Val Bormida faces the Liguria region.

The four Piedmont Inner Areas are located in similar territorial contexts that determine common needs and strategies. Val Bormida is surrounded by the Bormida River, the Alta Langa and Monferrato hills, the Ligurian

Table 3. Total number of projects funded in each Inner Area and the number of projects focused on each thematic scope (Source: Authors' elaboration on OpenCoesione data).

Region	Area	Environment	Administrative capacity	Competitiveness of companies	Culture and tourism	Energy	Social inclusion and health	Education and training	Employment and work	Digital networks and services	Research and innovation	Transport and mobility	Total
Valle d'Aosta	Bassa Valle	1	1	19	2	0	3	5	6	2	0	2	41
	Grand Paradis	0	1	0	1	0	3	4	0	0	0	3	12
Piedmont	Val Bormida	0	1	0	3	1	8	7	0	0	0	2	22
	Val di Lanzo	0	1	0	4	0	7	4	0	0	0	2	18
	Valli Grana e Maira	0	1	3	1	3	1	10	0	1	0	3	23
	Val d'Ossola	0	1	0	2	2	4	1	0	4	0	2	16
Liguria	Antola Tigullio	0	1	0	8	0	4	3	0	4	0	5	25
	Beigua Sol	2	0	2	5	1	7	2	0	3	3	3	28
	Val di Vara	1	1	0	3	1	4	4	0	1	0	2	17
	Alta Valle Arroscia	4	1	1	3	1	5	4	0	1	2	2	24
	Alta Valtellina	0	1	39	5	9	2	0	6	0	0	0	62
Lombardy	Alto Lago di Como	0	1	49	13	7	3	2	10	0	1	0	86
	Appennino Lombardo Alto Oltrepò Pavese	0	1	21	18	6	2	4	0	0	0	0	52
	Valchiavenna	2	5	5	10	0	1	5	2	0	1	3	34
	Tesino	3	1	3	3	1	3	4	4	1	0	1	24
Trentino Alto Adige	Val di Sole	1	1	0	0	0	5	2	5	1	0	3	18
	Comelico	0	1	2	6	0	5	5	2	0	3	4	28
Veneto	Contratto di Foce Delta del Po	0	1	3	4	0	3	6	1	0	0	3	21
	Spettabile Reggenza	0	1	9	0	0	6	14	0	0	0	2	32
	Agordina	0	1	3	8	1	5	4	0	0	0	4	26
	Alta Carnia	0	1	5	0	2	0	7	0	0	13	0	28
Friuli Venezia Giulia	Canal del Ferro - Val Canale	0	0	10	3	0	4	13	2	0	0	2	34
	Dolomiti Friulane	0	0	1	0	0	0	0	0	0	13	0	14
	Alta Valmarecchia	0	1	3	1	6	5	7	0	0	0	2	25
Emilia Romagna	Appennino Emiliano	0	0	0	2	1	6	3	3	0	0	1	16
	Appennino piacentino-parmense	1	1	1	7	1	15	5	0	3	0	2	36
	Basso Ferrarese	0	1	8	5	0	2	3	4	1	0	1	25
Tuscany	Casentino Valliberina	9	2	6	0	0	13	9	0	0	2	7	48
	Garfagnana-Lunigiana - Media Valle del Serchio - Appennino Pistoiese	42	2	5	0	0	7	3	0	1	0	14	74
	Valdarno e Valdisevie, Mugello, Val Bisenzio	8	3	0	0	0	20	9	0	0	0	5	45
	Appennino basso pesarese e anconetano	0	1	2	13	0	0	9	0	1	0	1	27
Marche	Piceno	0	0	4	13	0	4	3	0	0	0	2	26
	Alto Maceratese	0	5	7	2	0	6	4	0	0	0	2	26
Lazio	Alta Tuscia Antica Città di Castro	4	0	5	1	0	0	11	0	0	0	6	27
	Monti Reatini	11	3	3	5	0	2	14	0	0	0	3	41
	Monti Simbruini	1	1	16	6	0	4	10	0	4	0	4	46
	Valle del Comino	1	1	4	11	0	4	4	1	0	0	3	29
Umbria	Nord Est Umbria	2	1	8	0	0	7	12	0	0	0	5	35
	Sud Ovest Orvietano	1	4	4	2	0	9	6	0	2	0	6	34
	Valnerina	0	2	9	0	0	11	10	0	1	0	0	33
Sardinia	Alta Marmilla	2	0	7	0	0	5	12	0	0	0	5	31
	Gennargentu Mandrolisai	0	0	9	0	0	2	4	0	0	0	3	18
	Alto Medio Sannio	0	1	0	15	5	1	6	0	0	0	3	31
Molise	Fortore	0	1	0	2	3	4	2	2	0	0	0	14
	Mainarde	0	1	0	1	1	0	0	2	0	0	2	7
	Matese	0	1	2	5	1	3	0	0	1	0	2	15
	Alto Aterno Gran Sasso Laga	0	6	5	1	0	5	7	0	0	0	5	29
Abruzzo	Basso Sangro-Trigno	3	2	0	2	0	3	8	0	0	0	4	22
	Gran Sasso-Subequana	0	0	3	3	0	4	10	2	0	0	3	25
	Val Vestino	0	3	8	0	0	2	7	3	0	0	4	27
	Valle del Giovenco - Valle Roveto	0	2	4	4	0	4	6	1	0	0	4	25
	Alto Bradano	2	1	2	7	9	8	10	5	0	0	9	53
Basilicata	Marmo Platano	0	0	0	0	3	4	3	0	8	0	19	37
	Mercure - Alto Sinni - Val Sarmento	0	0	0	21	39	10	5	0	3	0	13	91
	Montagna materana	2	0	0	14	13	7	6	0	1	0	27	70
	Grecanica	0	6	0	2	0	6	5	2	0	0	10	31
Calabria	Reventino Savuto	3	1	4	5	0	12	2	3	1	0	5	36
	Sila e Presila	0	6	4	3	0	0	1	0	3	6	8	31
	Versante Ionico Serre	0	0	4	15	0	11	6	0	0	0	0	36
	Alta Irpina	1	0	0	10	1	4	0	0	3	0	0	19
Campania	Cilento Interno	3	0	0	1	0	5	2	0	0	0	4	15
	Tammaro Terno	2	2	0	8	0	2	0	0	0	0	1	15
	Vallo di Diano	2	0	0	3	0	4	3	0	3	0	1	16
	Gargano	0	0	0	3	0	1	6	0	0	0	4	14
Puglia	Monti Dauni	1	0	1	13	5	0	14	0	0	0	14	48
	Sud Salento	0	1	2	3	0	0	0	0	0	1	3	10
	Alta Murgia	0	0	2	5	0	0	10	0	0	0	7	24
	Madonie	0	0	0	5	3	7	7	4	0	0	24	50
Sicily	Nebrodi	0	0	0	4	18	7	21	5	3	0	9	67
	Madonie	0	0	2	2	3	3	4	0	5	0	1	20
	Terre Sicane	0	0	2	0	2	2	4	4	0	0	3	17
	Valle del Simeto	2	4	1	0	10	5	3	1	2	1	14	43

Apennines and the Alps: the territory is hilly with variable altitudes, with also some mountainous areas (Strategia d'Area, 2020). Val d'Ossola consists of three different

valleys: Valli Anzasca, that is the most populous, and the smaller valleys Antrona and Bognanco, with a lower population density. This area is characterized by very small

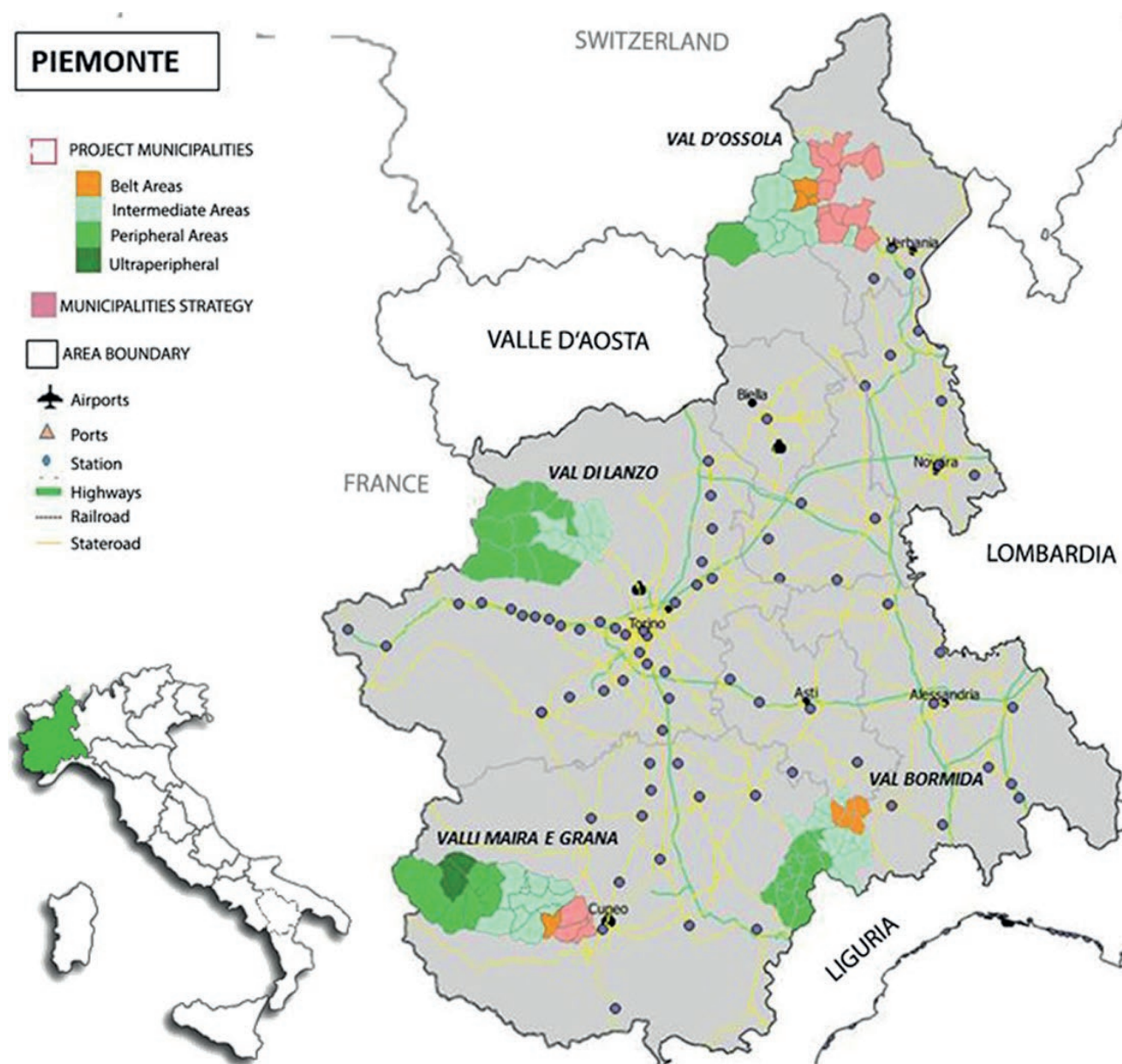


Figure 4. Piedmont Inner Areas founded by the first SNAI programming cycle (Source: Authors' elaboration on (Strategia Nazionale delle Aree Interne, 2020).

municipalities and villages mainly located at the bottom of the valley. The side valleys are characterized by inhabited centers positioned outside of the main routes (Bozza Strategia d'Area, n.d.). Val di Lanzo includes 3 valleys: Valle di Viù, characterized by the presence of lakes, Val d'Ala, which is the steepest, narrowest and wildest and preserves a great variety of alpine habitats, with woods, rocks and glaciers, and Val Grande, that is the northernmost of the three valleys, and has a wide valley floor (Accordo di programma quadro Regione Piemonte, 2020). Finally, Valli Maira and Grana can be divided

into three areas based on their altitude: low, medium and high valleys. The municipalities in the lower valley possess features that make them well-suited for easy settlement development. The middle and upper valley sections have a very impervious territorial conformation characterized by the absence of road crossings (Strategia Nazionale Aree Interne, 2020). Table 4 shows the general geographical characteristics of these areas and their main SNAI strategy goals.

Table 4 shows that Val d'Ossola, Val di Lanzo and Valli Maira and Grana are located at a higher altitude

Table 4. Geographical characteristics and main SNAI strategy goals of the 4 Piedmont Inner Areas (Source: Authors' elaboration on SNAI data).

Piedmont Inner Areas	Number of municipalities	Area size (km ²)	Average altitude (masl)	Number of inhabitants 2011	Density per inhabitant (inhab/km ²)	SNAI strategy main goals
Val Bormida	28	516	431	12,741	51.2	· Recovery and Enhancement of the territory · Cohesion of a community
Val D'Ossola	10	466	728	4,214	9	· Saving of natural resources and energy · Enhancement of the creative and social function of work · Circular economy
Val Di Lanzo	19	694	781	23,928	33.95	· Initiatives related to the enhancement of health, education, and mobility issues
Valli Maira and Grana	18	712	954	13,209	18.71	· Strengthening and implementation of essential services (Education and training; Public transport; Social and health services)

Table 5. Public funds and the number of projects related to the prevailing thematic scopes in the 4 Piedmont Inner Areas (Source: Authors' elaboration on OpenCoesione data).

	Val Bormida	Val D'Ossola	Val Di Lanzo	Valli Maira and Grana	Total (in Piedmont Region)
<i>Projects numbers and thematic scopes</i>					
Total number of projects	22 (28%)	16 (20%)	18 (23%)	23 (29%)	79
Prevailing thematic scope based on the number of projects	Social inclusion and health	Social inclusion and health/ digital networks and services	Social inclusion and health	Education and training	Education and training
Number of projects of the prevailing thematic scope	8 (10%)	4 (5%)	7 (8,8%)	10 (12,6%)	22 (27,8%)
<i>Projects amount of public funds and thematic scopes</i>					
Total amount of public funds	6,889,330.00 € (20%)	6,612,500.00 € (19%)	9,077,500.00 € (27%)	11,640,000.00 € (34%)	34,219,330.00 €
Prevailing thematic scope based on funds	Culture and tourism	Energy	Culture and tourism	Education and training	Education and training
Public funds of the prevailing thematic scope	1,413,428.00 € (4%)	1,060,000.00 € (3%) / 2,527,500.00 € (7%)	1,802,790.00 € (5%)	4,714,000.00 € (14%)	7,239,637.00 € (21%)
Number of projects of the prevailing funds	3 (3.7%)	2 (2.5%)	4 (5.0%)	10 (12.6%)	22 (27.8%)
Public funds of the most funded projects	1,950,000.00 € (6%)	3,000,000.00 € (9%)	2,852,500.00 € (8%)	4,714,000.00 € (14%)	7,239,637.00 € (21%)
Average project funding for the main thematic scope (Number of projects)	176,678.50 €	265,000.00 € / 631,875.00 €	257,541.43 €	471,400.00 €	329,074.41 €
Average fund per project of the prevailing thematic scope (project funds)	650,000.00 €	1,500,000.00 €	713,125.00 €	471,400.00 €	329,074.41 €

than Val Bormida. The main SNAI strategy goals were different and demonstrated that the strategies were developed and personalized on each territory. Val di Lanzo and Valli Maira and Grana addressed similar strategies on education, mobility and health issues, while

Val Bormida focused on social issues and Val d'Ossola on sustainable-energy challenges.

Table 5 presents the total number of projects and the funds allocated to the four Inner Areas of Piedmont. In terms of the total number of projects, the thematic scope

Table 6. Comparison between Piedmont Inner Areas strategies (Source: Authors' elaboration on SNAI data).

	Val Bormida	Val di Lanzo	Valli Maira and Grana	Val D'Ossola
Administrative capacity	Technical assistance	Technical assistance	Economic and financial management of the programme, Communication and monitoring plan	Technical assistance
Competitiveness of companies	Development of non-agricultural enterprises	Enhancement of the agricultural, agri-food and forestry sectors, Development of digital services for tourism	Creation of a territorial brand, Development of entrepreneurial activities, Improvement and support of the socio-economic context	/
Culture and tourism	Digital platform for tourist services, Enhancement of local heritage	Creation of a widespread cultural network, Protection of areas of environmental value	Promotion and marketing of local products, Providing services useful for tourist use	Environmental enhancement of the thermal baths, design and construction for the development of the wood supply chain, digitization of the Ossola museum, recovery of nuts and bolts
Energy	Energy efficiency of public buildings	/	Energy saving and production of electricity from renewable sources	Construction of a hydroelectric plant for the production of self-consumption, Construction of wood chip cogeneration units
Social inclusion and health	Telemedicine, widespread medical centers	Telemedicine, widespread healthcare, Coordination of the activity of healthcare professionals Strengthening of pharmacies	Integrated family assistance services	Telemedicine, community nurses, RSA territorial service networks, development and training action for the Alpine mountains
Education and training	Educational workshops, opening of new nursery schools	Networking of local schools, activation of new study paths	Construction of a new school complex, making the school complex safe, expanding the school training offer	Extension of school openings
Digital networks and services	/	Reorganization and optimization of local public transport, Activation of flexible transport services	Broadband and ultra-broadband services	/
Transport and mobility	Mobility reorganization, Creation of collective transport services	New runways to land helicopter rescue	TPL efficiency Creation of supplementary services in the area and ride sharing	Enhancement of local public transport, Preparation of a public transport on call for tourists

on 'Social Inclusion and Health' predominated in three of the Inner Areas, although at the regional level, 'Education and Training' emerged as the most significant thematic scope. When considering the total amount of public funds, 'Culture and Tourism' was the primary focus in Val Bormida and Val di Lanzo, whereas in Val d'Ossola, 'Energy' took precedence. In Valli Maira and Grana, the largest share of funds was allocated to 'Education and Training'.

An analysis of the number of projects by frequency for each Inner Area of Piedmont and thematic scope, as shown in Table 3, reveals that no projects in Piedmont were directed towards the thematic areas of 'Environment', 'Employment and Work', or 'Research and Innovation'. The highest number of projects were addressed

towards "Social inclusion and health", "Education and training", "Culture and tourism", while just few projects towards "Competitiveness of companies" and "Digital networks and services". Focusing the attention on the specific issues that characterized the SNAI strategy goals in Piedmont, Table 6 summarizes them by means of keywords for each Inner Area and thematic scope.

Results highlight that projects "Social inclusion and health", "Administrative capacity", "Culture and tourism" were quite similar, while those related to "Education and training", "Digital networks and services", "Energy" reflected the specific needs of the territory. Moreover, the projects related to cultural issues and to the organization of transports were rather similar.

5.3. Lacks of thematic scopes in Piedmont SNAI strategies

As mentioned before, the 4 Piedmont Inner Areas decided not to address their strategies and investments towards the following thematic scopes: “Environment”, “Employment and Work” and “Research and Innovation”. Therefore, a deeper analysis of the projects related to these scopes developed at the national level could be useful to address new strategies in the context of the second SNAI programming cycle. By understanding the strategic approaches and related implementations adopted in other Inner Areas, some best practices can be identified and similar initiatives can be developed elsewhere. Table 7 compares, for each thematic scope, the number of projects at the national level and in the Piedmont region, highlighting the Italian Inner Area that developed the highest number of projects related to each scope.

Therefore, in order to focus on those thematic scopes that were not considered in Piedmont during the first SNAI programming cycle, the Italian Inner Areas to be analyzed are the following: Garfagnana-Lunigiana - Media Valle del Serchio - Appennino Pistoiese (for “Environment”), Alto Lago di Como and Valli del Lario (for “Employment and work”) and Alta Carnia (for “Research and innovation”).

The Garfagnana-Lunigiana - Media Valle del Serchio - Appennino Pistoiese Inner Area, located in Tuscany Region, directed a large number of projects towards environmental issues (57%), although it is notable that these projects accounted for only a small percentage of the total invested funds (10%). Table 8 shows a detailed breakdown of the number of projects and the total funds allocated both for the whole strategy and for the “Employment and work” projects.

This Inner Area strategy was focused on the mountainous areas, where signs of structural weakness emerged, including the significant distance from essential services, which had led to depopulation, an ageing population, loss of functions, and inadequate soil protection (Accordo di programma quadro Regione Toscana, n.d.). The general goal was to counter these factors by leveraging the specific characteristics of the territory and its communities – territorial identity and sense of belonging – and the growing local development model, particularly the tourism-rural sector, enhancing local agricultural production, historical centers, and landscape and environmental assets.

According to the characteristics of its environment, this Inner Area sets the protection of the territory as a relevant scope through two lines of intervention: prevention against hydrogeological instability and seismic mapping of the building heritage of the entire area (Accordo di programma quadro Regione Toscana, n.d.). The high potential risk of landslides, floods, and seismic events represents a constant threat to the area. By considering the continuous and recent natural disasters, the maintenance and protection of the territory emerged as a priority to improve its safety, which is not sufficient and, above all, not focused on the actual needs of the inhabitants. The interventions were mostly reactive and focused on restoring structures and areas damaged by events after they had occurred, leaving little room for comprehensive prevention programs. The goal set by the Inner Area was to shift from a “damage repair” policy to a prevention policy through the maintenance of surface water networks, minor water bodies, vegetation clearing, and restoring full functionality of rainwater disposal systems. These actions aimed to make the area more attrac-

Table 7. Number of projects at the national level and in the Piedmont region for each thematic scope (Source: Authors’ elaboration on SNAI data).

	Number of projects at national level	Number of projects in Piedmont region		Inner Area with the highest number of projects
Environment	117	0	42	Garfagnana-Lunigiana - Media Valle del Serchio - Appennino Pistoiese
Administrative capacity	90	4	6	Alto Aterno Gran Sasso Laga / Grecanica
Competitiveness of companies	318	3	49	Alto Lago di Como and Valli del Lario
Culture and tourism	327	10	21	Mercure – Alto Sinni – Val Sarmeto
Energy	155	6	35	Mercure – Alto Sinni – Val Sarmeto
Social inclusion and health	331	20	20	Valdarno e Valdisieve, Mugello, Val Bisenzio
Education and training	406	22	21	Nebrodi
Employment and work	80	0	10	Alto Lago di Como and Valli del Lario
Digital networks and services	64	5	8	Marmo Platano
Research and innovation	46	0	13	Alta Carnia / Dolomiti Friulane
Transport and mobility	323	9	27	Montagna materana

Table 8. Garfagnana-Lunigiana - Media Valle del Serchio - Appennino Pistoiese: number of projects and the total amount of public funds (Source: Authors' elaboration on SNAI data).

Garfagnana-lunigiana - Media Valle del Serchio - Pistoia Apennines		
	Whole strategy	"Environment" Projects
Total number of projects	74	42 (57%)
Total amount of public funds	5,723,859.58 €	594,092.73 € (10%)
Average fund per project	77,349.45378 €	14,145.065 €

Table 9. Alto Lago di Como and Valli del Lario: number of projects and the total amount of public funds (Source: Authors' elaboration on SNAI data).

Alto Lago di Como And Valli del Lario		
	Whole strategy	"Competitiveness of companies" projects
Total number of projects	86	49 (57%)
Total amount of public funds	8,029,561 €	1,961,250 € (10%)
Average fund per project	93,367 €	40,026 €

tive and livable for the population, who could, in turn, contribute to its better maintenance and the promotion of economic activities. The expected results included the implementation of a widespread maintenance plan with a preventive focus on mitigating hydrogeological instability, as well as the optimization of maintenance efforts for surface water drainage systems, reducing the need for costly restoration and recovery interventions. From a seismic risk point of view, the establishment of a database available for the classification of risk situations represented the indispensable step towards the precise seismic qualification document and the definition of precise preventive consolidation interventions (Accordo di programma quadro Regione Toscana, n.d.).

The Alto Lago di Como and Valli del Lario Inner Area, located in Lombardy Region, presented both the highest number of "Employment and work" (10 projects) and of "Competitiveness of companies" (49 projects); however the strategy is clearly aimed at improving the competitiveness of companies. Table 9 shows in detail that there is a proportional distribution between the number of projects and the amount of public funds.

This Inner Area strategy was oriented towards a strong territorial cohesion action aimed at recomposing the fragmentation, freeing up energy and supporting excellence (Accordo di programma quadro Regione Lombardia, n.d.). The identified priorities for strategic

Table 10. Number of projects and total public funds (Source: Authors' elaboration on SNAI data).

Alta Carnia		
	Whole strategy	"Research and innovation" projects
Total number of projects	28	13 (46%)
Total amount of public funds	1,994,680.11 €	1,249,542.70 € (63%)
Average fund per project	71,238.60 €	96,118.70 €

actions were two: *i*) strengthening territorial networks for a reorganization of functions and relationships that overcomes the conditions of fragmentation and lays the foundations for a systemic vision of the area; *ii*) working on and with young people, to strengthen their skills and abilities to move in the labour market, but also to increase their awareness and proactivity regarding the effective opportunities that this Inner Area can offer in terms of life and professional opportunities (Accordo di programma quadro Regione Lombardia, n.d.). In particular, a strategy goal was to strengthen industrial manufacturing excellence, which so much shaped the economy and the local labour market. Nevertheless, to be able to maintain its condition and position in the international markets on which it competes, it was considered important to strengthen both industrial research activities for the innovation of processes, products and organization and the training of workers to make them more capable of combining traditional knowledge with the opportunities provided by the research itself (Accordo di programma quadro Regione Lombardia, n.d.).

Lastly, the Alta Carnia Inner Area, located in Friuli Venezia Giulia Region, presented the highest number of "Research and innovation" projects. Table 10 shows that about half of the proposed projects are focused on research and innovation issues, which are related to more than 60% of public funds.

The strategy of this Inner Area was aimed not only to reverse the increase in the number of inhabitants (due to depopulation trend) that impacted also on productive activities and services, but also to enhance some strategic sectors, related to forest resources, tourism, as well as natural resources (Accordo di programma quadro Regione Friuli Venezia Giulia, n.d.).

Instead, the primary goal of the local SNAI strategy was twofold: *i*) to ensure the well-being of residents by strengthening essential services (education, health and mobility); *ii*) cultivating the area's potential and appeal from a tourism perspective by supporting local economy chains.

This strategy was focused on the development of research innovation projects and was supported by local actors from the territory, such as Mountain community, Policy Coordination Service, Region, Regional Administration, as well as active workers of the area. The active involvement of local communities had a twofold objective: to inform the residents and to outline the SNAI strategy on the basis of data, experiences, and feedback. The constant dialogue between stakeholders along the whole strategy definition process enabled the selection of choices that are truly suitable for the area.

6. DISCUSSION AND RECOMMENDATIONS

The findings of this research highlight critical lessons for the second SNAI cycle (2021-2027), emphasising the importance of a more context-specific and flexible approach to improve effectiveness. This is particularly relevant in light of the most recent release (2023) of the OpenKit indicators (Nucleo di valutazione e analisi per la programmazione, 2023) which provides updated metrics and methodological guidance for monitoring and planning. One key insight is that Inner Areas should not be treated as homogeneous entities: while they share common challenges – physical and digital marginality, depopulation, and weak local economies – each area has unique socio-economic and environmental characteristics that require tailored solutions. The adoption of a shared but adaptable approach, avoiding rigid and pre-defined processes, is crucial for success.

Furthermore, the Covid-19 pandemic has introduced new dynamics that policymakers must consider. The increased preference for housing in rural areas and the expansion of remote work present opportunities for repopulation, but only if adequate digital infrastructure is in place. Addressing the digital divide is therefore a priority, as access to reliable internet is now an essential service, much like healthcare or transport. Marginal areas should offer not only essential services but also a high quality of life (Stankulova et al., 2023; 2024) to attract new residents.

Another key policy implication is the need for better coordination between national strategies and local governance. While top-down policies provide essential funding and a general framework, bottom-up engagement is crucial for ensuring that interventions reflect the specific needs of each territory. Strengthening the role of local authorities and community stakeholders in decision-making processes would enhance policy effectiveness and project sustainability.

Moving forward, the next step of this research will be to monitor the management and impact of the second

SNAI cycle strategies. However, challenges remain in collecting updated and reliable data, as unclear responsibilities regarding data reporting and accessibility continue to hinder transparency. Additionally, future studies will investigate why some areas were not reconfirmed in the second SNAI cycle and whether the pandemic and economic crisis influenced the distribution of projects and funds. By learning from past shortcomings and refining strategic planning, Inner Areas can transition from marginality to vibrancy, becoming sustainable and thriving communities.

7. CONCLUSION

Inner Areas represent marginal and fragile territories, both environmentally and, more significantly, from social, economic, and institutional perspectives. The first cycle of the National Strategy for Inner Areas (SNAI) aimed to address long-standing and deeply rooted challenges in these regions. As Raffestin (Raffestin, 1989) emphasized, planning and investment in fragile areas, particularly in mountain regions, require a careful balance between environmental, social, and economic dimensions, as they continuously interact in a process of rebalancing. However, the findings of this study suggest that the first SNAI cycle did not always achieve this balance (Cinieri and Tognon, 2021).

The analysis of 2258 projects across the 72 Inner Areas funded by the first SNAI cycle revealed that the distribution of funds did not always correlate with the number of projects or local needs. For instance, ‘Transport and Mobility’ received 80 million euros with relatively few projects (149), while ‘Competitiveness of Companies’ had a much larger number of projects (559) but less than 20 million euros. One surprising finding was the lack of attention to environmental projects, despite the fact that addressing environmental risks was a key SNAI objective (2014-2020), especially given the known challenges of hydrogeological instability and inadequate territorial protection (Pessina, 2021). Similarly, ‘Competitiveness of Companies’ and ‘Digital Networks’ saw limited focus. Additionally, the lack of projects in the ‘Employment and Work’ scope contrasts sharply with the widespread issues of depopulation and youth migration from these areas, which hinder local business development.

To contextualize the analysis of the examined projects at the national level, it is important highlighting that official data from the Department for Cohesion Policies and the South were integrated with other data sources. For instance, according to the former Agency for Territorial Cohesion, regional fact sheets provided a synthetic

overview of demographic, economic, and social indicators for regions and autonomous provinces, along with data on national and EU resources allocated to cohesion policies during the 2007-2013 and 2014-2020 programming cycles (<https://politichecoesione.governo.it/it/>).

Additionally, the analysis was based also on the Italian National Institute of Statistics (ISTAT) database, containing 366 indicators available at the regional level, by macro-area, and for the target areas of different development policy cycles. These sources provided official data for understanding the relevance of the examined projects in a regional context, enabling a more in-depth analysis that was directly correlated to the national dimension.

From a methodological standpoint, this study presents both strengths and weaknesses. The use of open government data allowed for a comprehensive, large-scale assessment of the first SNAI cycle, identifying patterns and discrepancies in funding allocation. The Exploratory Data Analysis (EDA) provided valuable insights into how different regions approached development challenges. However, limitations include incompleteness and inconsistencies in available data, which complicate efforts to track project outcomes. Moreover, this study primarily focused on funding allocation, while qualitative aspects – such as the effectiveness of interventions and local perceptions – require further investigation.

Regarding the initial research question – How were funds and projects distributed in the first SNAI cycle, and what lessons can be drawn for future planning? – the findings indicate that funding distribution was uneven across thematic areas and territories, often misaligned with local priorities. This suggests that a more tailored and participatory approach is needed to improve future interventions.

A more in-depth analysis was carried out at the regional level, focusing the attention on Piedmont Region, to explore how the Valsesia new Inner Area could exploit the lessons learned from the four previous Piedmont Inner Areas to improve its strategy definition process. During the first SNAI cycle, Piedmont's Inner Areas displayed diverse strategies, tailoring interventions to local needs. While Val di Lanzo, Valli Maira, and Grana prioritized education, mobility, and healthcare, Val Bormida focused on social issues, and Val d'Ossola emphasized sustainable energy.

However, in Valsesia the SNAI strategy definition process was marked by significant uncertainties and critical issues, particularly in identifying local priorities and selecting the thematic scopes to address the overall strategy, specific actions and the related funding. The analysis of other Piedmont Inner Areas showed both best practices and pitfalls, which could guide Valsesia's

future strategy and foster a stronger stakeholder involvement, better alignment between funding and territorial needs, and a more integrated long-term vision for economic development.

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Unleashing the hidden green value: assessing the impact of energy certification and environmental amenities on real estate through hedonic modelling

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Abstract. Rapid population growth and urbanization have intensified energy demand and climate vulnerability in cities, elevating the importance of urban green spaces and energy-efficient properties, which impact real estate values. This study uses a hedonic pricing model to assess how environmental amenities and energy efficiency influence property prices. We analysed sales contracts from 2022–2023 in Padua (Italy), enriched with spatial data on key environmental factors. Findings reveal a notable price premium associated with proximity to green spaces and waterways: for each hectare of park area, properties located within 100 m experience a 5.4% price increase, while each additional 100 meters from a waterway reduces apartment value by 3.7%. Additionally, apartments in energy class A or higher command a 30% higher price per square meter with respect to other energy classes. This research offers valuable insights into how urban green spaces and energy efficiency shape real estate values in rapidly urbanizing settings.

Keywords: building's energy performance, hedonic model, urban environment.

JEL codes: Q49, Q51, R30.

1. INTRODUCTION

The world's population is three times larger than it was in the mid-twentieth century, growing from 2.5 billion in 1950 to 8 billion in 2022, and it is projected to reach up to 9.7 billion in 2050 (United Nations, 2022). Around 55% of this total currently lives in urban areas and this share is projected to reach 68% by 2050 (United Nations, 2019).

The increasing number of people in the cities coupled with the consequences of climate change, such as higher temperatures, floods, and excessive drought is increasing the vulnerability of the population living in urban

areas (Ebi et al., 2021; Li et al., 2022). Some recent examples include the heatwaves in Europe that caused approximately 63 thousand deaths during the summer of 2022 and the floods of May 2023 in the Emilia Romagna region (Italy), which affected 100 municipalities with 23 rivers flooded and 1,000 landslides (Ballester et al., 2023; Priolo, 2023; Sabelli, 2023).

Urban green areas, for instance parks with natural elements such as trees, grass, and water bodies play an important role in the mitigation of climate change and improvement of social cohesion in cities (European Commission, 2019; Petzold and Mose, 2023). Urban greenery is known for improving not only physical and mental health (clean air, aesthetics, recreation, noise reduction, temperature regulation) but also improving biodiversity (creation of habitats) and economy (water infiltration, increase in real estate value of dwellings located near the green areas) (Campagnaro et al., 2020; Lungman et al., 2023; Ma et al., 2019; Tempesta, 2015).

In addition to these benefits, the need to spend time outdoors and reduce stress levels led to an appreciation of urban green areas, which became even more prominent after the COVID-19 pandemic. In some regions, the visitation to natural areas increased considerably during and after that period, especially those places near urban centres where access was easy and possible (da Schio et al., 2021; Grima et al., 2020; Sikorska et al., 2023). The increased demand for urban green areas is reflected in real estate transaction prices: studies using hedonic pricing models (HPM) (Rosen, 1974) in different countries show that properties located closer to an urban green area or a natural feature, such as a water body, present a price premium, whereas houses located in a polluted and noisy area tend to have a lower value (Cordera et al., 2019; Dell'Anna et al., 2022; Escobedo et al., 2015; Osland et al., 2022).

The Hedonic Pricing Model (HPM) posits that the price of a real estate asset is determined by its intrinsic and extrinsic characteristics. In this respect, the HPM provides a framework to measure the value of each characteristic directly influencing the price of a dwelling (Rosen, 1974), thus revealing the effects, among others, of environmental quality on house prices. More recently, the accessibility of public georeferenced data has facilitated the utilization of Geographic Information Systems (GIS tools) in generating more refined environmental variables for model inputs, including factors like the proximity of dwellings to green areas.

The amenities potentially influencing the price of a dwelling, however, are not just related to extrinsic factors such as accessibility (e.g. proximity to services, such as schools and supermarkets) and environmental qual-

ity (e.g. presence of green areas nearby and air quality), but also to intrinsic characteristics, such as its energy efficiency which is indicated in the Energy Performance Certificate (EPC). Initiatives related to energy efficiency have become even more important at the European Union (EU) level in recent decades due to its linkage to the climate goals set around carbon neutrality by 2050. Since buildings are responsible for 40% of EU energy consumption and 36% of energy-related greenhouse gas emissions, the EPC is an important policy tool towards a zero-emission economy (European Commission, 2021). The EPC was introduced to measure how energy efficient is a building, also in comparison to other buildings. First mentioned in the Energy Performance of Buildings Directive (EPBD) 2002/91/EC, it has become mandatory in the EU member states, which means that any building, house, or apartment must have an EPC at the moment of their sale/lease to inform potential buyers about the energy performance of the dwelling (European Parliament and Council of the European Union, 2002). The directive was revised in 2010 (Directive 2010/31/EU-Recast) and 2018 (Directive 2018/2002/EU) with increased standards, such as stating the EPC in advertisements of dwellings, mandatory targets of energy coming from renewable sources, minimum performances, and an increasing number of “zero energy buildings” (European Parliament and Council of the European Union, 2010, 2018). In 2024, the European Parliament approved the revised Energy Performance of Buildings Directive (EU/2024/1275) to align with the objectives of the European Green Deal and expedite the renovation of older buildings while acknowledging the differences among EU countries in terms of existing building stocks, geography, and climate. Member States will have until 29 May 2026 to incorporate its requirements into their national laws (European Parliament and Council of the European Union, 2024).

Even though there is a growing body of literature using hedonic models to estimate the effect of energy efficiency and environmental quality on housing prices, there are still conflicting results and a lack of studies tackling both aspects simultaneously. This is especially true in Italy, where only a few studies were found dealing either with energy efficiency or only with environmental quality (see Amrusch (2005); Bonetti et al. (2016); Copiello and Coletto (2023); Cordera et al. (2019); Fregonara et al. (2017); Guerri et al. (2022)). We argue that both attributes jointly influence housing demand. Including both in the same hedonic framework not only reflects the full set of environmental qualities valued by households but also allows us to disentangle private versus public pathways to sustainability, thereby offering a more holistic understanding of urban hous-

ing markets, avoiding omitted variable bias. A further aspect that deserves attention in the current literature is the fact that most of the studies that applied the HPM to analyse the effect of EPC on the real estate market in Italy used the dwellings' asking prices instead of actual transactions. This is because obtaining real transaction data is challenging, as transaction prices are not readily accessible or publicly available in the country (Bisello et al., 2020; Manganelli et al., 2019). According to some authors (Kolbe et al., 2021), the use of asking prices instead of real transaction data, however, could lead to upward bias and large error variance in the estimates.

Considering the gaps in the current literature, the aim of this paper is twofold: *i*) to assess the effect on apartment prices of extrinsic factors, including environmental quality, and *ii*) to estimate the influence of energy efficiency (as measured by the EPC) and other intrinsic characteristics on apartment prices. The originality of this paper lies in *i*) the simultaneous analysis of the effect of both private (energy efficiency) and public (green amenities) environmental characteristics on property values, which offers guidance to both private actors and policymakers on where to focus resources for maximizing housing value and sustainability benefits; and *ii*) the use of transaction data from sales contracts instead of asking prices derived from real estate listings.

The paper is organized as follows: after a literature review in section 2, section 3 introduces the study area and the methodological steps of the hedonic modelling. In section 4, the results are reported along with their interpretation. The findings are discussed in section 5 and section 6 presents the conclusions of the study.

2. PREVIOUS STUDIES

An extensive body of literature explores the relation between house prices and either environmental amenities or energy performance, presenting a notable expansion in number over time (Fregonara and Rubino, 2021; Schaeffer and Dissart, 2018). The HPM is one of the most employed methodologies for estimating these effects. In this section, we delve into the various environmental factors and energy performance indicators used in hedonic models documented in the literature.

2.1. Valuation of environmental amenities in the housing market

The effect of environmental amenities on the housing market has been investigated through hedonic models by researchers since the end of the last century.

For instance, in the 1980s, by estimating hedonic models with 781 house sales in Boston (US), Li and Brown (1980) found that the higher the distance to river, ocean, or recreational area, the lower the price of houses. Additionally, the influence of environmental aspects on property prices has grown over time. In a study developed in Singapore, Teo et al. (2023) estimated that during the 1990s tree cover represented 9.2% of the sales price of an apartment unit; this increased to 10.9% during the 2000s; and 11.7% during the 2010s. The increasing appreciation of green urban areas was related to their decreasing quantity and quality over time.

The environmental quality in urban and peri-urban areas has been explored through different variables, such as air quality (Chay et al., 2005; Cordera et al., 2019; Franco and Cutter, 2022; Freeman et al., 2019; Hitaj et al., 2018), proximity to a water body (Anderson and Vahe, 2018; Bonetti et al., 2016; Dell'Anna et al., 2022; Sander and Haight, 2012; Schaerer et al., 2008), water quality (Bonetti et al., 2016; Moore et al., 2020), landscape composition (Allen Klaiber and Phaneuf, 2010; Luttik, 2000; Sander and Haight, 2012; Schaerer et al., 2008; Schläpfer et al., 2015), proximity to green areas (Anderson and Vahe, 2018; Conway et al., 2008; Dell'Anna et al., 2022; Franco and Macdonald, 2018; Łaszkiwicz et al., 2019; Osland et al., 2022; Panduro and Veie, 2013; Plant et al., 2017; Wu et al., 2022), view of green areas (Jim and Chen, 2006; Morancho, 2003; Panduro and Veie, 2013; Sander and Polasky, 2009; Wasson et al., 2013; Wu et al., 2022) and features of the green areas, such as size and shape (Anderson and Vahe, 2018; Conway et al., 2008; Franco and Macdonald, 2018; Liebelt et al., 2018; Shinozaki et al., 2019).

Focusing on examples of characteristics related to green urban areas, a study carried out in the United States identified that green parks' size and proximity have a small but statistically significant effect on housing prices: the increase of 1% in park area results in the increase of house sales price by 0.03%, and a 1% decrease in distance from the park results in an increase of 0.016% in the sales price (Poudyal et al., 2009). Still in the US, another study found a positive effect of the presence of trees within the property, with its value increased by US\$1,586 per tree present in the dwelling area (Escobedo et al., 2015). In Portugal, the tree canopy coverage in urban areas (Lisbon) also presented a positive effect on property prices, with a 0.20% increase in price from each squared kilometre increase in the relative size of the tree canopy, equal to approximately €400 per dwelling (Franco and Macdonald, 2018).

In terms of accessibility and size of green areas, a study in the UK showed that the presence of a small

functioning green space within 200 meters of a property increases its price by 0.5%, and the greater the size of the green area, the greater the premium, reaching up to 1.4% (Anderson and Vahe, 2018). In Singapore, the distance to a park presented a negative effect on the price of dwellings, meaning the longer the distance from a park, the lower the property price, with an average house price reduction of USD 181.67 for one meter of increasing distance (Dell'Anna et al., 2022). Similar results were found in China, where a 1% improvement in accessibility to green parks results in a 1.6% increase in price and that properties with a higher percentage of green area within a 300 m radius have higher values, with each percentage point of green space adding 2.1% to the price per square meter (Kong et al., 2007). On the other hand, another study of house asking prices in China showed that the view of a green area is more important than its accessibility or size (Wu et al., 2022). In Norway, environmental amenities such as proximity to a lake, green park dominance, and ocean view showed a significant and positive effect on dwellings transaction prices, presenting premiums of 13.7%, 7.3%, and 3.8% respectively (Osland et al., 2022).

In Italy, more specifically in the city of Florence, Guerri et al. (2022) found that residential buildings with the highest values were in thermally neutral zones (outside of hotspots related to urban heat island), characterized by the presence of high green and blue infrastructure (tree cover and water bodies). In Milan, Borgoni et al. (2018) found that the size and proximity to green areas also showed a positive relation to housing prices. Only one study focused on the city of Padua using environmental quality aspects and spatial econometrics, but it focused on air quality and used listing prices from real estate agencies' websites (Amrusch, 2005).

When it comes to the blue infrastructure, the literature shows that the size and proximity to a water body play a positive role in property price (Anderson and Vahe, 2018; Cohen et al., 2014; Luttik, 2000; Sander and Haight, 2012). Such a relation depends on the quality of the water. For example, Bonetti et al. (2016) found that in Milan the proximity to a canal was considered an amenity in heavily anthropic areas since it improves the environmental conditions, whereas the proximity to a stream has a negative effect on price, decreasing property value, due to the poor water quality of the streams located in the city.

2.2. Valuation of energy efficiency in the housing market

Studies show that at the global level, energy labels positively influence housing sales prices, with the mere

presence of an energy label correlating to an average price premium of 4.2%, with the highest premium observed in North America (5.36%) (Cespedes-Lopez et al., 2019). Focusing on Europe, some differences between residential and commercial buildings, as well as between sales and rents emerged: for the price of residential buildings, an increase of 3-8% due to energy efficiency improvements was found, and for residential rents, the premium was of around 3-5%. The increase in prices is higher for commercial buildings, with premium prices over 10% and rental prices being positively affected by 2-5% (Zancanella et al., 2018).

At the country level, many studies showed a positive effect on housing prices deriving from more efficient EPC classes (Goel, 2023; Marmolejo-Duarte et al., 2020; Taruttis and Weber, 2022). On the other hand, some studies that also used hedonic models showed that EPC only modestly impacted listing prices (Fregonara et al., 2017; Marmolejo-Duarte and Chen, 2019) or did not affect price at all (Olaussen et al., 2017, 2021; Olaussen et al., 2019; Wilhelmsson, 2019).

In Italy, to the best of our knowledge, Fregonara et al. (2014) were the first to analyse EPC ratings' influence on real estate. Focusing on the city of Torino, they used a sample of 577 buildings collected in 2012, the year that marked the beginning of the mandatory inclusion of EPC in advertisements of dwellings for sale in Italy. Results from the hedonic models showed a weak relationship between listing price and high energy efficiency levels. One of the explanations was that the potential buyers were not yet aware that a higher investment in energy-efficient houses meant lower maintenance costs in the future, and so this was not reflected by real estate agencies. Such a weak relationship was confirmed by Fregonara et al. (2017) in a subsequent study. More recently, however, according to Barreca et al. (2021), price premiums presented an increasing trend in Torino, with low EPC labels (E, F, and G) significantly and negatively affecting housing prices, while high EPC labels (B, A1, A2, A3, and A4) presented a smaller but positive influence on them.

Still in Northern Italy, more specifically in Bolzano, a premium of 6% was found for properties moving from the worst energy performance class (G) to the best (A) (Bisello et al., 2020). The authors used hedonic models based on 825 listing prices. Moving to Southern Italy, in the city of Bari, studies using transaction prices identified premiums from 27% to 29% in properties presenting EPC class A (Manganelli et al., 2019; Morano et al., 2020). The first study calculated the premium by comparing class A dwellings to those not belonging to class A whereas the second study compared class A dwellings

to those belonging to class G. The lowest EPC (class G) presented a similar but negative effect (-27%) when compared to dwellings not belonging to this class (Morano et al., 2020). In Reggio Calabria, an evolutionary polynomial regression using a sample of 515 residential properties identified a premium of 41% on sale prices of properties presenting the highest energy performances (EPC class A or B) when compared to class G (Massimo et al., 2022).

Specifically in Padua, Copiello and Bonifaci (2015) not only found that EPC has a statistically significant influence on house prices, but that it can reach up to 22% of premium price if the dwelling is class A (the highest EPC), when compared to class G (the lowest EPC). More recently, Copiello and Coletto (2023), by using a spatial autoregressive model, found a price premium of 55% for dwellings of class A4 when compared to those of class D, class G in this case presented a 29% decrease in unit price when compared to class D.

3. METHODOLOGY

3.1. The hedonic model

In nonmarket valuation, the HPM is a key component of Revealed Preferences Methods (RPM), alongside the Travel Cost method, and is widely applied in real estate (Herath and Maier, 2010). RPM are grounded in the idea that the value of many environmental amenities or disamenities can be inferred from people's purchasing decisions related to market goods. Observing real market choices enables the estimation of these values (Boyle, 2003). The HPM is theoretically underpinned by Rosen's model (Rosen, 1974) and Lancaster's consumer theory (Lancaster, 1966) and is used to estimate the value of a good or service by breaking it down into its constituent attributes.

This model is particularly useful in real estate markets, where the price of a dwelling is influenced by a combination of characteristics. These characteristics may encompass intrinsic attributes, which are those features directly related to the property itself (e.g., number of bedrooms, year of construction), and extrinsic attributes, which are beyond the property's limits but still affect it (e.g. local school quality, proximity to amenities). Therefore, the price of the i^{th} house can be modelled as a dependent variable of its characteristics:

$$P_i = f(I, E, L, t) \quad (1)$$

where P is the rent or price of the house; I refers to property-related attributes (intrinsic characteristics); E refers to extrinsic characteristics (environmental and

non-environmental); L refers locational variables (when a spatial model is applied) and; t is an indicator of time (Malpezzi et al., 2002). Equation (1) can then be specified as:

$$P_i = K + a_1x_1 + a_2x_2 + \dots + a_ix_i + \dots + a_nx_n \quad (2)$$

where K is a constant, a_i is the regression coefficient, and x_i is a characteristic of the dwelling. From an economic point of view, in the case of linear models, a_i corresponds to the marginal price of each characteristic, that is the price increase determined by a unitary increase of the independent variable (Rosen, 1974). The linear regression in Equation (2) is commonly turned into a log-linear regression by taking the natural logarithm of the dependent variable (Equation (3)).

$$\ln(P_i) = K + a_1x_1 + a_2x_2 + \dots + a_ix_i + \dots + a_nx_n \quad (3)$$

This is also the model specification we used in our study. In the case of continuous variables, it is possible to interpret the coefficients (a_i) as the percentage change of the property price (P) due to marginal changes in the independent variables (x_i), while in the case of discrete or dichotomous variables the percentage change of P can be calculated as follows (Halvorsen and Palmquist, 1980):

$$\frac{\Delta P}{P} \bullet 100 = (e^{a_i} - 1) \bullet 100 \quad (4)$$

3.2. Study area and data

The study area being considered is the municipality of Padua, located in the Veneto region, north-eastern Italy. Padua is located approximately 35 km west of Veneto's capital Venice (Figure 1) and covers an area of 93 km² with a population of 206,500 inhabitants (ISTAT, 2011, 2023). Padua is the capital of the most densely populated province in the region of Veneto: the homonymous province presents an average of 429.7 inhabitants per km² (ISTAT, 2011).

Padua is geographically situated within an alluvial plain area, between two relatively large rivers: the Brenta and the Bacchiglione (Comune di Padova, 2004). The city is characterized by a sub-continental climate, marked by a minimum average temperature of 1°C in January, a maximum average temperature of 30°C in July, and annual average precipitation of 913 mm, based on data spanning the period 1994-2022 (ARPAV, 2023).

The transaction data of apartments in Padua was obtained through the Italian Revenue Agency (Agenzia delle Entrate) web portal, which contains sale contracts that were officially registered by the Agency. The select-



Figure 1. Location of the study area. The study area is the municipality of Padua, located in the Veneto region (in grey), Northeastern Italy. The map was generated using QGIS software.

ed transaction period was from July 2022 to February 2023. To minimize the influence of inflation and other economic factors on property values, we opted for a relatively short sales period. At the same time, we ensured the selected timeframe provided a sufficient number of observations for robust analysis. The data collection resulted in a dataset of 398 transactions; however, only 321 were complete and suitable for the data analysis, since in some contracts there was missing information on some characteristics needed for the model. Of this total, only 222 were in the “apartment” category. Only apartments were considered since it would not be correct to compare different goods (e.g. houses, commercial buildings, attics, etc.). Among the different types of buildings, we chose to focus on apartments, as they are by far the most common type of dwelling in the city.

While 222 observations might appear limited, this sample size is considered appropriate when analyzing transaction data in a medium-sized Italian town, given the challenges in obtaining such data. In Italy, transaction data is neither readily accessible nor publicly available. To collect this information, one must register with the Italian Revenue Agency and manually download individual sales contracts in PDF format. Data are then extracted analyzing each sale contract “manually”, and

this procedure is highly time consuming. Furthermore, a large quota of the analyzed contracts are usually dismissed, due to partial sales (only a quota of the ownership of the building is being sold), or because the object of the transaction is not suitable for the research (transactions of garages or commercial buildings for example). In contrast, asking prices are significantly easier to collect. However, as previously introduced, relying on asking prices instead of actual transaction data can introduce upward bias and greater error variance in estimates. This is because sellers often list properties at prices much higher than their eventual sale price. Additionally, sellers and realtors may overestimate the influence of certain variables on property prices, further compounding biases.

Along with the transaction price (€/m²) of apartments in Padua - the dependent variable - the predictors are listed in Table 1 and Table 2. The majority of the variables presented in Table 1 and Table 2 are self-explanatory, but some need further details. The “Energy class” represents a dummy variable indicating (value 1) if the EPC equals to A (namely A1, A2, A3, A4), while it assumes value 0 for all other classes (B, C, D, E, F, and G). “Elevator” is a dummy variable assuming value 1 if the elevator is present and 0 if it is absent, while “Mediation” assumes value 1 if the transaction was mediated by a real estate agency. As mentioned in section 3.1, a semi-log model was preferred, enabling a direct interpretation of percentage variations in price resulting from unit changes in the independent variables.

Our data source, the sale contracts, includes details on the transaction price of the apartment, its address, cadastral information, surface, blueprint, EPC, year of construction, presence and age of the heating system, and other contract specifications (e.g. personal information of the buyer(s) and the seller(s)), which characterized the intrinsic factors to feed the hedonic regression. By extracting the cadastral data found in the contract of each apartment, it was possible to enrich the transaction database by retrieving the geographic coordinates through the online application Formaps (<https://www.formaps.it/>), which was crucial for spatial analysis. By importing the coordinates of each property into a GIS platform (QGIS software version 3.28.1), additional variables were generated for each building, thus characterizing the extrinsic factors, namely: *i*) the Euclidean distance from the property to the train station; *ii*) number of schools within a radius of 200 m; *iii*) number of supermarkets within a radius of 200 m; *iv*) urban parks area within a radius of 100 m; *v*) urban parks area between 100 and 200 m; and *vi*) the Euclidean distance of each apartment to the nearest water-

Table 1. Continuous variables summary statistics.

Variable	Unit	N	Min	Q1	Median	Mean	Q3	Max	SD*
Price	€	222	27,300	105,000	140,000	212,527.1	247,500	935,000	178,987.5
Unit price	€/m ²	222	380.2	1,140.6	1,746.4	1,999.9	2,597.4	5,252.8	1,071
Apartment surface	m ²	222	28	75.2	97	105.3	124	434	52.8
Age of the apartment	years	222	1	30.5	53	52.6	63	173	30.4
Year in which the heating system was installed	years	222	1915	2002	2009	2007.6	2015	2023	11.3
Bathrooms number	number	222	1	1	1	1.3	1	4	0.5
Train station distance (Km)	Km	222	0.4	1.3	2	2.4	3.1	5.5	1.3
Number of schools within a radius of 200 m	number	222	0	0	0	0.2	0	2	0.4
Number of supermarkets within a radius of 200 m	number	222	0	0	0	0.4	1	4	0.8
Waterway distance (Km)	Km	222	0	0.2	0.4	0.5	0.7	1.4	0.4
Urban parks area (ha) within a radius of 100 m	ha	222	0	0	0	0.6	0.6	6.8	1.4
Urban parks area (ha) between 100 and 200 m	ha	222	0	0	0	0.6	0.6	6.8	1.5

* SD = Standard Deviation.

Table 2. Categorical variables summary statistics.

Variable	Levels	N	Percent
Energy class A*		222	
	0 B, C, D, E, F, G	201	91%
	1 A, or greater	21	9%
Elevator		222	
	0 absent	124	56%
	1 present	98	44%
Mediation**		222	
	0 absent	92	41%
	1 present	130	59%

* Dummy indicating EPC class A (A1, A2, A3, A4) value = 1, other classes (B, C, D, E, F and G) value = 0.

** Whether the transaction was mediated by a real estate agency.

way. The distances were measured in meters, and the area was measured in square meters. The buffer considered, namely a 200 m radius, was chosen based on the average distance between properties and urban parks, which was of 181 meters.

The location of supermarkets, train station, schools, and waterways, was collected through the “Quick OSM” plugin in QGIS. The geoinformation on the different land uses, including urban parks, was downloaded from the geoportal of the Veneto Region (<https://idt2.regione.veneto.it/>).

The age of the buildings was modelled in a parabolic fashion, to take into account that typically both historical and newer buildings have a positive effect on the transaction price. More specifically, the parabolic relation between price and age implies that the older (historical) or newer (with highest comfort and better energy performances) the dwelling the higher the price (Figure 2).

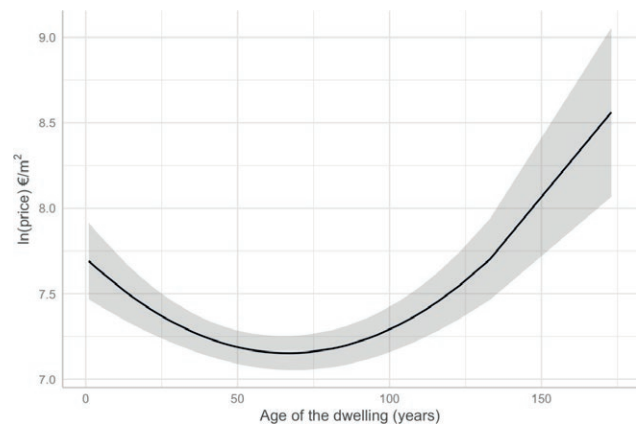


Figure 2. Estimated effect of age on property price in the study area. Quadratic relation between the natural logarithm of price (€/m²) and the age of the dwellings in the dataset (black line = predicted values, grey bound = 95% confidence interval). The analysis was conducted using R software.

Once all the variables were generated, the hedonic models were analysed using R version 4.2.3. The goodness-of-fit of the models was obtained by conducting the F-test, adjusted R-Squared test on common OLS models. To avoid collinearity, variables presenting a Pearson correlation coefficient superior to 0.5 were removed from the models. We also checked for the existence of overall multicollinearity by measuring the variance inflation factor (VIF).

4. RESULTS

The 222 apartments found in the sales contracts for the selected period are distributed throughout Padua as

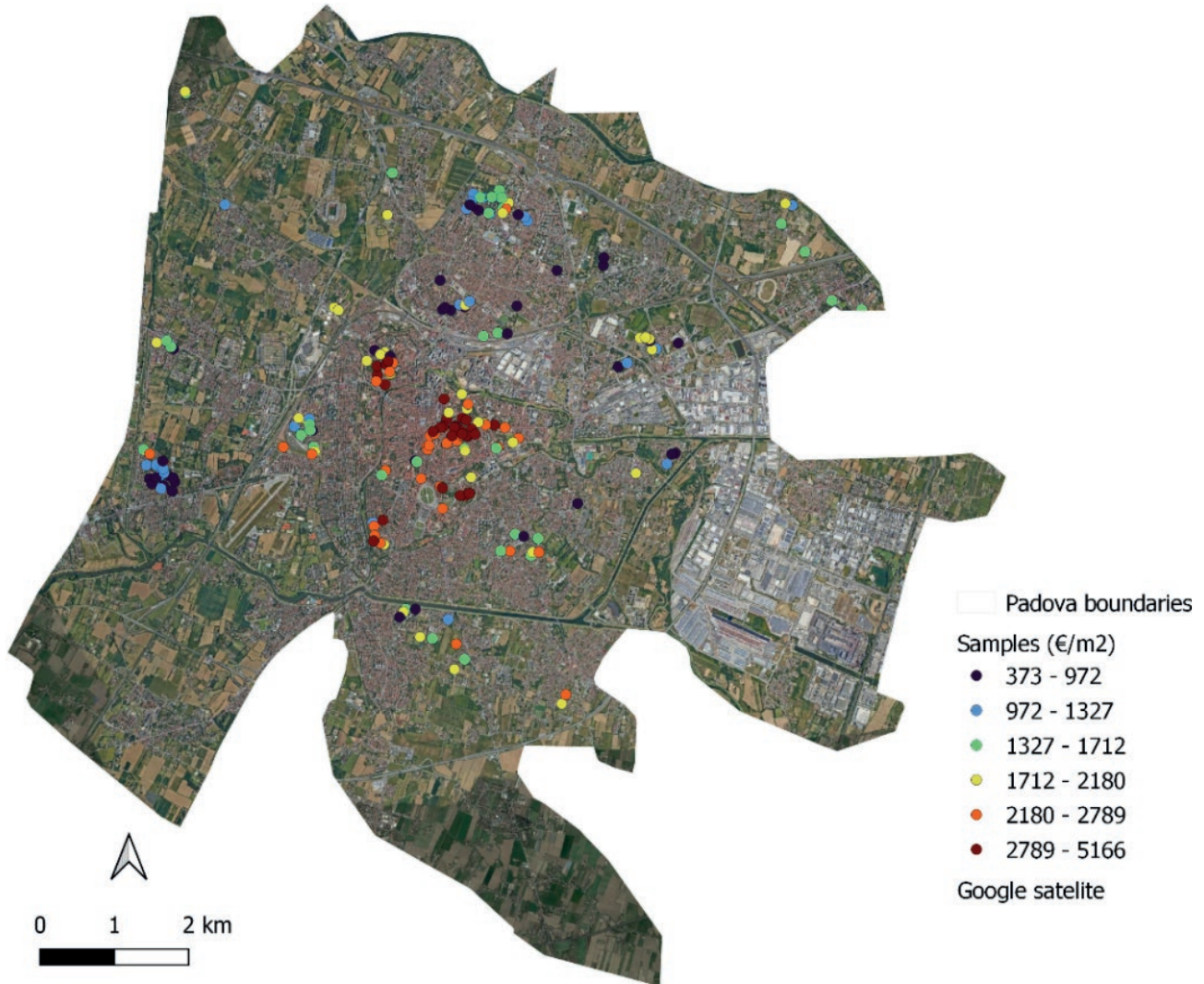


Figure 3. Observations' distribution. Map of the municipality of Padua containing the observations represented by dots ranging from dark blue (lowest price per square meter) to dark red (highest price per square meter). The map was generated using QGIS software.

illustrated in Figure 3. Notably, apartments exhibiting higher values (depicted in red) are concentrated in the city centre, while those in blue and green hues, indicating lower values, are situated at greater distances from the city centre. The observations were distributed across different areas of the city, with a slight concentration in the city centre. This reflects the reality of the local real estate market, as the city centre typically exhibits a more dynamic real estate market. Additionally, the peripheral areas of Padua are predominantly characterized by rural and industrial activities, with few to no apartments present. As a result, no transactions were recorded in those areas during the selected period.

The model results (Table 3) were estimated by using the 222 apartment sales in Padua, with the logarithm of

unit transaction price in €/m² serving as the dependent variable as described in Equation (3). Only independent variables that were significant with at least 90% probability were included in the model. There are no collinearity phenomena in the model ($VIF < 2$) with the sole exception of age and age squared.

Regarding the intrinsic characteristics of the apartments, the model highlights that the price per square meter decreases as the surface area increases. Every additional square meter of surface decreases the price by 0.34%. Additionally, the presence of two bathrooms and a lift is significant, and they both increase the price per square meter by 17%.

Estimating the impact of energy class on price is complex due to potential collinearity issues, as recently

Table 3. Hedonic model results. Dependent variable: log of apartment prices per square meter (€/m²).

Variables	Coefficients	p-value	Price (€/m ²) % variation
Constant	-5.651		
Apartment surface (m ²)	-0.00347	****	-0.34
Energy class A	0.265	**	30.34°
Age of the apartment	-0.0166	****	
Squared age of the apartment	0.000125	****	
Year in which the heating system was installed	0.00691	***	0.69
Bathrooms number	0.173	***	17.35
Elevator	0.161	****	17.42°
Train station distance (Km)	-0.123	**	-12.32
Number of schools within a radius 200 m	0.122	**	12.18
Number of supermarkets within a radius 200 m	0.0965	***	9.65
Urban parks area (ha) within a radius of 100 m	0.0541	***	5.41
Urban parks area (ha) between 100 and 200 m	0.0393	**	3.93
Waterway distance (Km)	-0.366	****	-36.6
Mediation	0.11860	**	12.59°

Observations = 222 / R-squared = 0.551 / Adjusted R-squared = 0.521 / St. Error of the model = 0.378.

° Calculated using Equation (4).

Note: * p<0.10, ** p<0.05, *** p<0.01, **** p<0.001.

built apartments typically belong to the highest energy classes. However, the energy class is in some ways a proxy for the age of the property and therefore, by omitting this last characteristic, the effect of the energy class can be overestimated. From the estimated model in which the age of the property is inserted, it emerges that: (i) apartments belonging to energy class A or greater increase the price per square meter by 30 %. We reduced the energy classes in the model to two classes (\geq A, all other classes) because in further exploratory analyses we found that apartments belonging to other energy classes did not have a statistically significant effect on the price.

As to the effect of age, it is interesting to note that in the city of Padua this variable presents a parabolic trend (Figure 2 and Table 3). Including both the linear and squared terms allows us to account for the possibility that price does not decline uniformly with age. Instead, the relationship may follow a U-shaped curve (Figure 2), where price initially decreases with age (captured by the negative linear coefficient in Table 3), but beyond a certain point, the effect of age becomes less negative or even slightly positive (captured by the positive squared term in Table 3). This pattern can reflect architectural or historical value in older buildings, or improvements made over time. More specifically, it causes the price of the property to decrease until the age of 67, after which the price per square meter increases. It can be deduced that, at least generally, the oldest properties built before the Second World War are more appreciated by the market

for their architectural characteristics or for their location closer to the city centre.

The last intrinsic characteristic analyzed, the year of installation of the heating system, presented a positive effect on the price, regardless of the energy class to which it belongs (0.69% for each additional year).

Regarding the extrinsic non-environmental characteristics, the model highlights that proximity to some services increases the price of the property. The price decreases by 1.23% as the distance from the train station increases by 100 m. The number of schools within 200 m increases the unit price by 12.2% and the number of supermarkets by 9.6%. These estimates align with the urban income theory, which posits that the willingness to pay for a property also depends on future costs associated with accessing the diverse range of essential services.

Concerning the environmental characteristics, two variables are significantly correlated to the price: the area occupied by urban parks within a radius of 100 m and from 100 to 200 m and the distance from waterways. When it comes to the urban parks variable, it should be noted that their effect is statistically significant up to a distance of 200 m. It can also be seen how the effect decreases as the distance of public greenery from the home increases: one hectare of park located less than 100 m from the home increases the price by 5.4%, this premium drops to 3.9% for parks placed at a distance between 100 and 200 m. The distance from waterways also has a significant effect on the price of houses: for

every additional 100 m of distance from the waterway, the apartment price is reduced by 3.7%.

Finally, the model demonstrates that a subjective characteristic unrelated to the property itself or the provision of economic, social, and environmental services can influence house prices. Specifically, when an apartment was sold through a real estate agency (mediation), the premium was on average 12.6% higher. This could be due to Italian legislation, which mandates that the price declared in the sales deed must match the actual price paid if a real estate agent is involved. Alternatively, it is possible that real estate agents are able to increase the sales price or that they predominantly handle higher-priced properties, resulting in a higher average unit price.

5. DISCUSSION

From the analysis of the transaction contracts and geospatial data, some clues regarding the effect of environmental characteristics on property prices have emerged. The findings indicate a statistically significant influence of both energy efficiency and extrinsic environmental factors on apartment prices in Padua, represented by price premiums.

First, the price premium of 30% found for best-performing apartments (EPC=A) is consistent with the literature which has been showing the increased importance of energy performance on real estate. The estimated price premium found in this study is somewhat similar to the one of Massimo et al. (2022) in the Italian municipality of Reggio Calabria where a 41.5% premium was found for residential properties presenting EPC A or B compared to other energy classes. Using an intermediary baseline (EPC=D) in the same city explored in the present study, Copiello and Coletto (2023) found a premium price of 55% for apartments belonging to EPC=A4 and a decrease of 29% for those with EPC=G. Price premiums were also found in other parts of Italy, such as in the municipality of Bolzano, where a premium of 6% was found for properties moving from the worst energy performance class (G) to the best (A) (Bisello et al., 2020). In Bari, studies using transaction prices identified premiums from 27% to 29.41% in properties presenting EPC>A (Manganelli et al., 2019; Morano et al., 2020) and a decrease of 27% for the worst-performing dwellings (EPC=G) (Morano et al., 2020).

In the context of examining the influence of energy performance on the real estate market, a relevant observation arising from our study is the correlation identified between the apartment's age and its EPC rating. Within our sample, newly built apartments exhibit superior

energy performance, introducing the potential for contrasting conclusions. Divergent approaches exist in the literature: some studies incorporate both age and EPC in their models (e.g. Barreca et al. (2021); Manganelli et al. (2019); Morano et al. (2020)), while others opt for a singular variable, with EPC serving as a proxy for additional factors such as a building's age or simply because other attributes are not significantly affecting price (see Bisello et al. (2020); Copiello and Coletto (2023); Massimo et al. (2022)). Certain authors consider this correlation problematic, as omitting variables correlated to the EPC may lead to overlooking the impact of the selected variable on price (Olaussen et al., 2017).

Regarding extrinsic environmental variables, our findings suggest a positive effect of the proximity to water, illustrated by a 3.7% decrease in price for every additional 100 meters from the waterway, which aligns with the research of Bonetti et al. (2016) who identified an even stronger price decrease in Milan (Italy), of 7.4% for houses for an additional meter of distance from the canal. Taking into consideration the effect of blue spaces in general, our findings are somewhat aligned with Anderson and Vahe (2018), who identified a premium price of 0.9% for those properties located within 200 m from a small blue space in the UK. In the Netherlands, a 1.91% discount in price was found for properties located 25-50 m from the nearest water when compared to properties located less than 25 m away and the discount increased to -4.04% for properties positioned 200-400 m from the nearest water body (Koster, 2022). Another study in the Netherlands estimated a premium price of 7% for a house located within 1000 m from a lake, and this premium got up to 28% if the house was by the lake with a nice view (Luttik, 2000).

Finally, the effect of green urban areas is evidenced in our results by a 5.4% premium for an additional hectare of urban park located within 100 m of the apartment (and 3.9% for a distance between 100 and 200 m) aligns with existing literature regarding size and proximity of green features. The positive correlation between the size of the closest green parks and property value has been consistently supported by various studies. For instance, an additional 1% of green space within 500 m of apartments in Poland increased the sale price by 3.95 PLN per square meter (Czembrowski and Kronenberg, 2016). Similarly, in Finland, an additional 1 km in the distance to the nearest forested area resulted in a decrease of 5.9% in the price of the dwelling (Tyrväinen and Miettinen, 2000). In Costa Rica, Piaggio (2021) reported a 4% premium price for each additional 1% increase in size of the closest neighborhood park. Similarly to our findings, the authors also observed that dis-

tance alone was not a significant factor in their study area, as there were numerous parks within walking distance. Poudyal et al. (2009) in the United States identified that both the proximity and size of green parks impact property price. They found that a 1% increase in the park area corresponded to a 0.03% increase in house sales price, and a 1% decrease in distance from the park resulted in a 0.016% increase in the sales price. In the UK Anderson and Vahe (2018) demonstrated that the presence of a small functioning green space within 200 meters of a property led to a 0.5% increase in price, with larger green areas presenting greater premiums, reaching up to 1.4%. Parallel findings were observed in China, where a 1% improvement in accessibility to green parks results in a 1.6% increase in price and that properties with a higher percentage of green area within a 300 m radius have higher values, with each percentage point of green space adding 2.1% to the price per square meter (Kong et al., 2007).

6. CONCLUSIONS AND POLICY IMPLICATIONS

This article empirically tested whether EPC labels and extrinsic environmental characteristics affect housing transaction prices in the Italian city of Padua. By using a dataset composed of 222 sales contracts from July 2022 to February 2023, we estimated the influence of these various features through a hedonic pricing model.

Based on this sample, EPC labels influence the price of apartments, with a price premium for the best-performing ones (EPC = A or greater). The Energy Performance of Buildings Directive stands as the principal policy tool within the European Union for achieving energy efficiency goals, and since higher EPC labels indicate better energy performance, thus lower energy consumption and compliance with net zero emissions, this research serves as evidence that better energy performance is being capitalized to increased property price, which can motivate investors in renewing old buildings and developing new ones with EPC labels A, especially with the recast of the EPBD in 2024.

When it comes to environmental aspects, the small but significant effect of both the area occupied by urban parks and proximity to waterway on apartment price suggests that they are perceived as environmental amenities and are capitalized in the real estate market. This serves as indicators for various stakeholders, such as urban planners and investors, signaling the potential benefits of enhancing existing green spaces, investing in new ones, and developing residences within convenient walking distances from these amenities. The findings

also represent empirical evidence that water presents value beyond its direct use for drinking and agricultural purposes, representing aesthetic and recreational resources to urban residents.

The limitations of this study stem from its reliance on sales contracts obtained from the Italian Revenue Agency. Although this approach avoided the biases often associated with asking prices, it resulted in a smaller sample size and lacked detailed information on intrinsic property characteristics, such as condition or renovation status, which are not present in sales contracts in the country. While the reduced sample size may increase variance in the estimates, and the absence of certain variables could impact model accuracy or introduce bias, the findings reveal meaningful relationships that provide a strong foundation for future research. Building on these results, future studies could incorporate more detailed property data to further enhance the robustness and precision of the model, offering even greater insights into price determinants. Additionally, as a suggestion for future research, considering the potential interaction among variables found in the regression analyses, further exploration through spatial models is recommended.

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Property valuation: a comparative analysis of innovative market approach methods

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Abstract. This research aims to illustrate and implement innovative methods for property valuation, by comparing their respective outcomes in terms of statistical accuracy and empirical reliability. In particular, the paper describes and compares three market approach methods through an application to a case study located in the city of Rome (Italy), in order to outline their ability to rationalise the assessment in dynamic contexts and minimise the professional valuer's subjectivity. This work represents a new reference for valuers, in order to refine their estimates and guarantee transparency in their use, avoiding the risk of black boxes that frequently characterizes mass appraisal techniques (e.g. neural networks, genetic algorithms, multiple regressions, etc.), for which constant updating of the database originating the price functions would be necessary to appropriately describe the current market conditions.

Keywords: property valuation methods, real estate market value, similarity coefficients, reliability coefficients, goal programming, maximum entropy principle, Lagrange multipliers.

JEL codes: C61, R30.

1. INTRODUCTION

In recent years, the real estate market has experienced periods of deep uncertainty, initially caused by the economic crisis linked to the pandemic COVID-19 and the consequent restrictive measures, and subsequently exacerbated by the current conflict between Russia and Ukraine. This emergency context has led to significant global volatility, with potential substantial repercussions on the real estate sector in terms of sales and prices (Kroll, 2024). In light of these dynamics, it is crucial to manage uncertainty in order to prevent or, at least, reduce the likelihood of systemic crises in financial and economic markets, as occurred with the USA subprime mortgage crisis in 2007. In this regard, Aronsohn emphasizes that uncertainty, even under "normal" conditions, is intrinsic to most market evaluations, as there is rarely a single reference price for property valuation (Aronsohn, 2020). Indeed, for each

asset, the appraiser must identify the optimal combination of comparable sales, i.e., those that are characterized by the greatest similarities with the subject, in order to obtain the most accurate value assessment (Gabrielli and French, 2021). In the real estate appraisal process, it is therefore essential to adopt operational principles such as fairness, objectivity and legality, in order to improve the quality of the evaluations. The difference between the actual and expected market prices represents the risk associated with real estate evaluation activity. Consequently, it is necessary to increase risk awareness among professional valuers, by improving their technical skills and moral qualities. In general, it is important to establish and refine a real estate appraisal mechanism that minimizes risks, increases efficiency, and ensures healthy sector development (Sun, 2019), thus reducing the number of inappropriate evaluations and overvalued properties compared to their actual market values. The need to address uncertainty in a historical context characterized by the advancement of information technology and the availability of numerous software packages capable of handling large amounts of data, surpassing human processing and analysis capabilities, has led to a revolution in the decision-making processes. This revolution has been driven by the adoption of innovative mass appraisal models (Pagourtzi et al., 2003), such as genetic algorithms (Morano et al., 2018), spatial analysis models (Anselin and Getis, 1992), fuzzy logic (Chi Man Hui et al., 2009) and artificial neural networks (Borst, 1991). Data, a key component in all sectors of the modern economy, are also fundamental in the real estate sector. However, as the latter is traditionally fragmented and heterogeneous, it has encountered more difficulties in implementing technological innovations (Festa, 2021). Indeed, available data often do not allow for an exhaustive, scientific, descriptive and interpretative analysis of real estate markets. These problems are particularly evident in the context of the Italian property market, which is characterised by limited competitiveness, a lack of transparency and the absence of complete and systematic surveys of data on the characteristics of properties and the actual prices of purchases, sales and rents (De Paola, 2024). This context makes it difficult to implement econometric procedures capable of adequately describing the price formation mechanisms of properties in specific markets (Tajani and Morano, 2018). Therefore, it is necessary to adopt “hybrid” evaluation models that, even in the presence of few comparative data, can provide sufficiently objective results independent of the appraiser’s parameters, thus ensuring effective and accurate property price evaluations and improving the assessment reliability of professional valuers’ reports (Domian et al., 2015).

The paper is structured as follows. Section 3 analyzes the main literature related to the rationalization of the comparable transactions’ method. Section 4 describes in detail the SGA, the OWASM and the MAXENT. Section 5 applies the three methods to a case study, consisting of a sample of residential units located in the city of Rome (Italy). Section 6 discusses the different outputs of the three methods’ implementation, by highlighting the potentialities and the limits of each one of them. Finally, in Section 7 the conclusions are drawn, summarizing the main results obtained and the possible future implications.

2. AIM OF THE STUDY

In the outlined framework, the present research aims to compare three market approach methods through an implementation to an Italian case study, by highlighting the potentialities and the limits of each one of them. The first method is the General Appraisal System (SGA), which is already well-known in the relevant scientific literature (Simonotti, 2006), as listed among the main market approach methods to be used at single property asset level by numerous Italian public and private entities guidelines as a method that respects the principles of European and International Valuation Standards (Agenzia del Territorio, 2011; Associazione Bancaria Italiana, 2024; Organismo Italiano di Valutazione, 2015). The SGA is able to automatically appraise both the property values and the implicit prices of the influencing factors, without any subjective and external assumption on the parameter contributions. Through the resolution of a linear system of equations, the SGA allows an endogenous assessment of the adjustment coefficients of the comparable selling prices. The second method is the Optimised Weighted Appraisal System Method (OWASM) and represents an evolution of the SGA, as it overcomes some limitations concerning the possible linear dependency relationships in the coefficients’ matrix and the frequent low empirical reliability of the implicit prices. The third method (MAXENT) (De Paola, 2024), is based on the integration of the Maximum Entropy Principle with Lagrange multipliers and represents an innovative and powerful tool for addressing the challenges currently facing the field of real estate appraisals. This principle is founded upon the notion that, in the presence of specific observed constraints, the probability distribution that is selected should be that which maximises the uncertainty, facilitating the natural development of statistical models that are optimised for entropy (Jaynes, 1957; Shannon, 1948). Nevertheless, as will be discussed, the practical

difficulty of precisely determining the implicit prices of the individual characteristics that affect the property market value is one of the operational limitations of this method. The study aims to provide a significant contribution to the issue of reliability and logical-operational rationality in real estate evaluation procedures, regardless of the basis of value that satisfies the terms of engagement. The research proposes a potential solution to the uncertain aspects that frequently intervene in the assessment of the percentage adjustments of comparable prices. In this regard, the research represents a fundamental advancement in property valuation, as the analyzed methods require few input data and are easily implementable. Furthermore, these methods can mitigate the black box risk associated with mass appraisal techniques (e.g., neural networks, genetic algorithms, multiple regressions), which necessitate constant updating to the databases underlying price functions. Moreover, it should be outlined that the proposed methods (in particular, the OWASM and the MAXENT) can constitute an integration to the canonical market-oriented methods for ordinary properties (e.g. residential units, offices, shops, etc.) and income approach methods, as the Discounted Cash Flow Analysis generally applied for special properties (e.g. hotels, nursing homes, cinemas, retail spaces, etc.), to provide additional tools to verify the results obtained. In this way, the research represents valid support for *i*) professional valuers, to increase the assessment reliability of their reports, *ii*) banks and real estate funds management companies, to verify the adequacy of the property assessments developed by external professional valuers, to identify the most appropriate strategies of investment enhancement for the investors, to periodically update the values of the properties according to the actual and current market trends, *iii*) government agencies, that, to ensure the fair value of the property taxes, can quickly verify the property market values.

3. LITERATURE REVIEW

Over the past century, the field of real estate appraisal has evolved a range of methods to effectively compare the values of assets that share similar, though not identical, characteristics. Real estate assets are typically heterogeneous and unique resulting in market prices that are shaped by a wide range of factors, including both location and physical attributes (Forte and Rossi, 1979). It is essential that these characteristics are documented in a standardized and uniform way (Roscelli, 2014). Based on the availability of data and the selected evaluation

approach, the appraiser can choose from a variety of methods outlined in the literature.

The International Valuation Standards (IVS) classifies three main approaches (IVSC, 2021): the market approach, the income approach and the cost approach. These may all be used to formulate an evaluation judgement using whatever basis of value is applicable (Arcuri et al., 2020; Glumac and Rosiers, 2020; Pagourtzi et al., 2003).

Among them, the market approach has the main advantage of providing for an objective reference – the selling prices of the comparables –, exempting the valuer from the need to appropriately justify the assumptions made on the estimation parameters adopted in the income approach (cap rate, terminal value, analysis period, etc.) and in the cost approach (depreciation functions, the market value of the area, etc.) (Tajani et al., 2020). Nevertheless, the market approach is not without its own inherent limitations.

The literature offers an extensive analysis of the comparable transactions method, also known as the sales comparison approach (SCA) method, focusing on objectifying the estimation of adjustment coefficients for comparable sale prices (Tajani et al., 2020). Several research has demonstrated that the selection of comparable properties can be affected by bias, as appraisers often overemphasize the empirical data they first encounter, while giving less weight to data acquired later (Lin and Chang, 2012). The typically small sample size used for comparison is a primary concern in this context, often resulting from periods of low market activity or from a market that is inherently thin, consistently characterized by a limited number of transactions (French and Gabrielli, 2004). Furthermore, it has been widely recognized that subjectivity and uncertainty are inherent aspects of appraisal techniques (Colwell et al., 1983; Lipscomb and Gray, 1990), especially when aligning the values of comparable properties with that of the subject property (Copiello et al., 2021). Additionally, the pronounced heterogeneity of properties within the local submarket can further intensify this challenge (LaCour-Little and Green, 1998; Tajani et al., 2020). Several researchers have proposed coefficients derived from regression analysis, employing multiple regression models as a reference for adjustments able to reduce the shortcoming of subjective judgment (Kang and Reichert, 1991; Todora and Whiterell, 2002). For instance, Colwell *et al.* (1983) focus on the SCA and illustrate how to derive adjustment factors using the ordinary least squares (OLS) method rather than relying on the appraiser's judgment. This highlights how the traditional need for appraiser-derived adjustment factors can be

entirely supplanted by multiple regression analysis (Isakson, 2002).

The real estate mass appraisal process, which generally relies on econometric analysis, focuses on valuing large groups of properties rather than individual assets. These methods have been extensively studied and tested, underscoring their significance. Some Authors investigate the interplay between property value, property characteristics, and urban socio-economic factors (Tajani et al., 2016, 2015), even though the implementation of regression techniques (Rossini, 2000; Yalpir et al., 2006).

However, the application of econometric methods is not always feasible. This limitation often stems from the challenges of obtaining sufficiently large and representative samples, a fundamental requirement of econometric techniques, or from the poor quality of available data. While the results may be statistically significant for understanding broader trends and general patterns across the population (Piccolo and Vitale, 1984), they often fall short when addressing specific, unique cases that inevitably arise in practical applications (Iovine, 2015).

Other studies (Borst and McCluskey, 2008; Bourassa et al., 2007; Goodman and Thibodeau, 2003) have focused on enhancing sample selection by identifying submarkets where the implicit price contributions of independent variables are more likely to be similar. For instance, Case *et al.* (2004) developed a two-stage method in which the residuals from a single-stage OLS model are used as predictors in the two-stage model. However, it has been noted that estimating adjustments using the traditional OLS model can be inefficient, due to errors that are not independent and identically distributed (Copiello et al., 2021). As a result, in the scientific literature alternative estimators have been explored, such as generalized least squares (GLS) procedures (Pace, 1998), and models like those proposed by Pace & Gilley (1998), which resemble spatial autoregressive (SAR) models to account for spatially correlated residuals within a single-stage model. Other Authors have proposed a variation of the SCA based on the concept of spatial weight matrices, that is a characteristic of SAR models, arguing that it has significant relationships with the geographically weighted regression (GWR) method (Borst and McCluskey, 2008). The majority of existing literature advocates for the analysis of similarity in selecting comparable properties or applying the adjustment grid method. Isakson (1988; 1986) introduced the Nearest Neighbors Appraisal Technique (NNAT), where the assessed marked value is determined by a weighted average of the actual sale prices of comparable properties. In NNAT, the weights are assigned based on a multidimensional similarity measure, giving greater weight to properties

that are more closely aligned with the subject property. This approach eliminates the need to calculate adjusted sale prices for the comparables. Vandell (1991) proposed a minimum variance method for selecting and weighting comparable properties, focusing on minimizing the variance among the adjusted values of comparable sales. Gau et al. (Gau et al., 1994, 1992) extended Vandell's approach by replacing the variance with the coefficient of variation as the measure to be minimized. In both methods, the adjusted values of comparable properties are calculated using the dollar additive technique and adjustment factors derived from OLS. Curto (2005) applied the analytic hierarchy process as a multi-parameter market approach method to better rationalize the assessment of implicit prices related to quality factors. A significant area of research deals with the use of similarity and reliability coefficients (Colwell et al., 1983; Simonotti et al., 2016), particularly in market-oriented valuation methods such as the Market Comparison Approach (MCA) (Ruggiero and Salvo, 2011; Tajani et al., 2020). These coefficients enable the expansion of the geographic area for identifying potential comparables, even including properties that exhibit a greater degree of dissimilarity (Ciuna et al., 2017). Similarity indexes are generally calculated by evaluating the differences in the descriptors of the properties being compared, while the reliability coefficient is determined by assessing the variations in their adjusted prices (Berto et al., 2020). While it is logical to assume that a larger dataset of comparable properties would lead to a more accurate appraisal, some methods based on the Maximum Entropy Principle and Lagrange multipliers suggest that a small transaction sample may suffice to achieve a reliable estimated value. Brown (2017) was the first to explore the effectiveness of entropy in addressing the inefficiencies of the real estate market, a concept further developed by Chen et al. (2020). In this context, the most recent studies have been carried out by Özdilek (2023) and De Paola (2024). In particular, Özdilek's study examined the integration of entropy measures in property evaluations, involving the modification and integration of the triadic estimates of price, cost, and income. The results obtained led to a significant improvement in the accuracy of the value measurement. De Paola's work explores the applicability of the Maximum Entropy Principle to real estate valuations with the support of Lagrange multipliers, emphasizing how this method can significantly enhance the evaluation precision.

This analysis demonstrates that, for valuation purposes, it is feasible to achieve accurate estimates even when market data is scarce. This can be accomplished by incorporating similarity coefficients or employing an entropic approach. Indeed, when faced with limited ran-

dom data, statistical methods become impractical, and mathematical attempts frequently yield results that contradict the market evidence.

4. METHODS

It is reasonable to assume that a larger set of comparable data leads to more accurate valuation results. However, when faced with the challenge of limited resources, it becomes essential to adopt methods that can ensure reliable outcomes despite the scarcity of available information data. In this context, the SGA, the OWASM and the MAXENT methods, which will be presented as follows, prove to be particularly effective. These methods are capable of successfully addressing this challenge, enabling the production of reliable assessments even from a limited sample of property transactions.

4.1. General Appraisal System (SGA)

The SGA serves as an evaluation model capable of ascertaining both the property value and the implicit prices of various influencing factors by solving a system of linear equations.

In the linear system of equations, the known terms are the prices of the comparable properties, while the implicit price coefficients (which are among the unknowns, along with the market value of the subject property) are derived from the differences in the corresponding characteristics between the comparables and the subject property. Therefore, in the general estimation system, the unknown variables are: the estimated price of the subject property (V) and the implicit prices of individual characteristics (p_i), where the index i refers to the n real estate characteristics. The known terms consist of the prices of the comparable properties (P_j), where the index j refers to the m comparables, and the differences in the corresponding values (x) of the characteristics, calculated as $(x_{ji} - x_{0i})$, where the index 0 refers to the subject property.

Thus, in comparing a generic comparable property (indexed by j) with the subject property (indexed by 0), the equation linking the price of the comparable P_j to the value of the subject property V can be expressed as a linear combination of the implicit prices and the differences in characteristics, as follows:

$$P_j = V + (x_{j1} - x_{01}) \cdot p_1 + (x_{j2} - x_{02}) \cdot p_2 + \dots + (x_{jn} - x_{0n}) \cdot p_n \quad (1)$$

This equation can be formulated for each comparison between the comparable properties and the subject

property, leading to the definition of a linear system of equations, where the index j ranges from 1 to n , resulting in a total of m equations.

$$\begin{cases} P_1 = V + \sum_{i=1}^n (x_{1j} - x_{0j}) \cdot p_i \\ P_2 = V + \sum_{i=1}^n (x_{2j} - x_{0j}) \cdot p_i \\ \dots \\ P_m = V + \sum_{i=1}^n (x_{mj} - x_{0j}) \cdot p_i \end{cases} \quad (2)$$

In matrix form, Equation (2) becomes:

$$[P] = [D] \cdot [p] \quad (3)$$

In which p represents the appraisal vector and P denotes the vector of known selling prices, as defined in Equations (4) and (5):

$$P = \begin{bmatrix} P_1 \\ P_2 \\ \dots \\ P_m \end{bmatrix} \quad (4)$$

$$p = \begin{bmatrix} V \\ p_1 \\ p_2 \\ \dots \\ p_n \end{bmatrix} \quad (5)$$

The matrix D represents the difference matrix, as defined in Equation (6), where $d_{ji} = x_{ji} - x_{0i}$. It is composed of the coefficients of the unknowns, with a value of 1 assigned both to the subject property and to the differences in the values of the explanatory factors.

$$[D] = \begin{bmatrix} 1 & d_{11} & \dots & d_{1n} \\ 1 & d_{21} & \dots & d_{2n} \\ \dots & \dots & \dots & \dots \\ 1 & d_{m1} & \dots & d_{mn} \end{bmatrix} \quad (6)$$

Within each equation, the unknown coefficients of the implicit prices are determined for each characteristic as the difference between the value of the comparable property (indexed from 1 to m) and that of the subject property (indexed as 0). The coefficient for the unknown value of the subject property is set to 1 in every equation.

The solution to this system of equations can be succinctly expressed in matrix notation as the product of the inverse of the coefficient matrix and the vector of known prices:

$$[P] = [D]^{-1} \bullet [p] \quad (7)$$

Depending on the characteristics of the coefficient matrix D , the following scenarios may arise:

- If the matrix of known terms is square and non-singular, meaning the determinant of D is non-zero, the system is determined. In this case, the inverse of D can be calculated, leading to a unique solution that provides both the estimated value and the unknown implicit prices.
- If the system is underdetermined (i.e., the number of equations is less than the number of unknowns, $m < n + 1$), the solution can be obtained using the Moore-Penrose generalized inverse technique.

$$p = D^T \bullet (D \bullet D^T)^{-1} \bullet P \quad (8)$$

- Finally, if the system is overdetermined (i.e., the number of independent equations exceeds the number of unknowns, $m > n + 1$), the solution is instead provided by the following relation:

$$p = (D^T \bullet D)^{-1} \bullet D^T \bullet P \quad (9)$$

The SGA is recognized for its compliance with International Valuation Standards and its scientific robustness. The real estate evaluations manual by Tecnoborsa (2018) integrates International Valuation Standards with Italian regulations, highlighting SGA as a key appraisal method that aligns with global best practices while addressing the specifics of the Italian context. Furthermore, numerous private guidelines and professional associations, including those cited by the Italian Revenue Agency (2011), acknowledge SGA's deterministic and multi-parameter nature, validating its use in professional practice for its transparency and operational versatility. The SGA is also endorsed by the International Valuation Standards (2015) as a model ensuring objectivity and accuracy in property valuations.

4.2. The Optimized Weighted Appraisal System Method (OWASM)

The SGA operates effectively under the assumption of a perfectly competitive market, where sufficient data are available and transactions are transparent. However, property markets rarely meet these conditions, as monopolistic competition is more commonly observed. Consequently, the SGA can only produce reliable results when a substantial amount of comparable data is accessible. In contrast, in atypical markets or when data

are scarce, the SGA may lead to uncertain outcomes. Therefore, the innovation of the OWASM lies in the introduction of similarity and reliability measurements as weighting coefficients in the SGA equation system, allowing to assign different importance to the comparables according to their respective degrees of similarity and reliability.

One measure that can be used to assess the similarity of individual properties within a sample of properties is based on the 'closeness' of their respective explanatory factors. In other words, greater comparability corresponds to closer proximity in the values of the property characteristics, while less comparability indicates greater differences among these values. Consequently, the 'degree of similarity' of comparable properties can be expressed as a function of the difference between the i -th characteristic of a comparable property and that of the subject property (Arcuri et al., 2020). This difference can in turn be expressed in absolute terms in Equation (10):

$$gs_a^{j*} = \frac{\sum_{j=1}^m \sum_{i=1}^n \left| \frac{x_{ij} - x_{i0}}{\bar{x}_i} \right| - \sum_{i=1}^n \left| \frac{x_{ij} - x_{i0}}{\bar{x}_i} \right|}{(m-1) \bullet \sum_{j=1}^m \sum_{i=1}^n \left| \frac{x_{ij} - x_{i0}}{\bar{x}_i} \right|} \quad (10)$$

where gs_a^{j*} is the indicator of the degree of similarity of a j^* generic comparable and \bar{x}_i is the average of the values assumed by the i -th characteristic in the sample collected (Colwell et al., 1983).

In order to identify outlier data, it is first necessary to compute all the adjustments for the various property factors and determine the adjusted prices from the evaluation table. As is commonly known, the adjusted prices should theoretically converge perfectly. Therefore, any anomalies can be detected by examining the differences among these adjusted prices (Ruggiero and Salvo, 2011). Consequently, the "degree of reliability" assigned to each comparable property, in relation to its adjusted price, is determined by the formula of Equation (11):

$$ga^{j*} = \frac{\left(1 - \left| \frac{P_{j*} - \bar{P}_j}{\bar{P}_j} \right| \right)^{m+1}}{\sum_{j=1}^m \left(1 - \left| \frac{P_{j*} - \bar{P}_j}{\bar{P}_j} \right| \right)^{m+1}} \quad (11)$$

where P_{j*} is the selling price of the j^* comparable and \bar{P}_j is the average selling price of the comparable sample collected (Simonotti et al., 2016).

The variation function exhibits an almost linear trend, with values ranging between 0 and $1/(m-1)$. In this context, the greater the difference between the adjusted selling price of the comparable property and the average selling price of the data sample, the lower

Table 1. Algorithm of the OWASM.

<i>Variables</i>	$V, p_i \quad i=1, \dots, n$	(12)
<i>Objective function</i>	$\min \left[\sum_{j=1}^m (P_j - V) \right]$	(13)
	$gs_a^{j*} = \frac{\sum_{j=1}^m \sum_{i=1}^n \left \frac{x_{ij} - x_{i0}}{\bar{x}_i} \right - \sum_{i=1}^n \left \frac{x_{ij} - x_{i0}}{\bar{x}_i} \right }{(m-1) \cdot \sum_{j=1}^m \sum_{i=1}^n \left \frac{x_{ij} - x_{i0}}{\bar{x}_i} \right }$	(14)
<i>Similarity constraints</i>	$ga^{j*} = \frac{\left(1 - \left \frac{P_j - \bar{P}_j}{\bar{P}_j} \right \right)^{m+1}}{\sum_{j=1}^m \left(1 - \left \frac{P_j - \bar{P}_j}{\bar{P}_j} \right \right)^{m+1}}$	(15)
	$\bar{P}_j = \frac{\sum_{i=1}^m P_j + V}{m+1}$	(16)
<i>SGA constraints</i>	$\begin{cases} ga^{1*} (P_1 - V) = \sum_{i=1}^n gs_a^{1*} (x_{1i} - x_{0i}) \bullet p_i \\ ga^{2*} (P_2 - V) = \sum_{i=1}^n gs_a^{2*} (x_{2i} - x_{0i}) \bullet p_i \\ \dots \\ ga^{m*} (P_m - V) = \sum_{i=1}^n gs_a^{m*} (x_{mi} - x_{0i}) \bullet p_i \end{cases}$	(17)
<i>Empirical constraints</i>	$p_i \geq 0 \quad i=1, \dots, n$	(18)

the reliability of that corresponding selling price. The inclusion of similarity and reliability coefficients enables the modification of Equation (2) within the SGA framework. Considering that the reliability coefficients pertain to the selling prices, while the similarity coefficients relate to the property's influencing factors, the system of equations can be reformulated as shown in Equation (17) in Table 1.

The OWASM aims to achieve the most optimal estimation solution by applying principles of goal programming. In this method, the key components of a goal programming problem can be outlined as follows: *i)* limited resources are represented by the market value (V) and implicit prices (p_i) to be evaluated (*variables* in Equation (12) of Table 1); *ii)* alternative uses are identified by the possible combinations of V and p_i that satisfy the model's estimation constraints; *iii)* the constraints include formulas for calculating similarity and reliability coefficients (*similarity constraints*, Equations (14), (15), (16) in Table 1), the SGA equation system modified by introducing similarity and reliability constraints (*SGA constraints*, Equation (17) in Table 1) and any *empirical constraints* (Equation (18) in Table 1) introduced by the evaluator according to the market knowledge and expected signs and/or values for the implicit prices; *iv)* assuming the comparables are appropriately selected, the *objective function* (Equation (12) in Table 1) seeks the market value (V) that is closest to the identified comparable sale prices (Tajani et al., 2020).

The principal advantage of incorporating similarity and reliability coefficients is that they address the constraints associated with implementing the SGA in scenarios where the difference matrix (D) comprises linearly dependent rows and/or columns. Nevertheless, despite the facilitation of the solution afforded by the integration of these coefficients, the empirical reliability of the outputs may be still opened to question. Indeed, one of the most common challenges with the SGA – an issue not always resolved merely by introducing similarity and reliability coefficients – is the empirical inconsistency in the signs and/or values of the implicit prices for the influencing factors.

4.3. Maximum Entropy Principle and Lagrange Multipliers (MAXENT)

The “Maximum Entropy Principle” model operates through a constrained optimization process that integrates the principle of maximum entropy with Lagrange multipliers. The objective of this approach is to maximize a specific function, which is characterized by the negative sum of Shannon entropy, adjusted by real estate prices. Moreover, this maximization is performed under the constraints of normalization and consistency moments.

In formal terms, applying the Maximum Entropy Principle with Lagrange multipliers involves analyzing a system described by a set of state variables, $\{x_1, x_2, \dots, x_N\} \equiv x$, where each configuration has a

certain probability of occurrence. Given that such systems often exhibit high dimensionality, with a large value of N , it becomes practical to focus on the distribution of specific functions of these states. These functions, denoted as $f_1(x), f_2(x), \dots, f_K(x)$, encapsulate certain properties of the system, and their average values, $\langle f_v(x) \rangle_{exp}$, can be computed. The goal is to identify a distribution, $P(x)$, that ensures the experimentally observed average values of the K functions, $\langle f_v(x) \rangle_{exp}$, align with their expected values, $\langle f_v(x) \rangle_P$, as determined by the distribution.

The following steps are outlined in a succinct manner for the sake of clarity. Readers seeking a more comprehensive understanding are directed to the De Paola (De Paola, 2024).

For the entropy function, the following expression is considered:

$$S[P] = - \sum_x P(x) \ln P(x) \quad (19)$$

The constrained maximization problem is then addressed, where the constraints are defined by the limited information available, which imposes:

$$\langle f_v(x) \rangle_{exp} = \langle f_v(x) \rangle_P \equiv \sum_x P(x) f_v(x) \quad (20)$$

with $V = 0, \dots, K$. and recognizing that the probability distribution must be normalized, the following approach is applied: by selecting $f_0(x) = 1$, we ensure that it equals the experimental value of 1. To address this problem, Lagrange multipliers are employed, introducing the K parameters $\{\lambda_\mu\}$ and the generalized entropy function:

$$S[P; \{\lambda_\mu\}] = S[P] - \sum_{\mu=0}^K \lambda_\mu [\langle f_\mu(x) \rangle_P - \langle f_\mu(x) \rangle_{exp}] \quad (21)$$

The optimization process is subsequently carried out on $S[P; \{\lambda_\mu\}]$ with respect to both the probability $P(x)$ and the parameters, subject two conditions as follows:

$$P_{me}(x) = \frac{1}{Z(\{\lambda_\nu\})} \exp \left[- \sum_{\mu=1}^K \lambda_\mu f_\mu(x) \right] \quad (22)$$

$$0 = \frac{\partial S[P; \{\lambda_\mu\}]}{\partial \lambda_\mu} = \langle f_\mu(x) \rangle_P - \langle f_\mu(x) \rangle_{exp} \quad (23)$$

with $Z_{me}(\{\lambda_\nu\}) = S_x \exp(-\lambda_0 - 1)$.

Explicitly writing $\langle f_\mu(x) \rangle_P$ and replacing the expression of $P(x)$ found in (22):

$$\langle f_\mu(x) \rangle_{exp} = \frac{1}{Z(\{\lambda_\nu\})} \sum_x f_\mu(x) \exp \left[- \sum_{\mu=1}^K \lambda_\mu f_\mu(x) \right] \quad (24)$$

Substituting the distribution $P_{me}(x)$ into (21), the following expression for the generalized entropy can be obtained:

$$S[P; \{\lambda_\mu\}] = \ln Z(\{\lambda_\nu\}) + \sum_{\mu=0}^K \lambda_\mu \langle f_\mu(x) \rangle_{exp} \quad (25)$$

5. CASE STUDY

To highlight the potential of the three market approach methods, a comparative case study is proposed. Five residential units have been considered, under the assumption that each comparable unit within the housing sample iteratively constitutes the subject for which the value is to be determined. This way has facilitated effective testing of each method and mitigated the randomness inherent in the results obtained from a single subject. For the three methods, the results have been compared in terms of differentials between the observed unit sales prices and their respective estimated values. For the SGA and the OWASM, the deviation of implicit prices has been also examined.

5.1. Context of the dataset

Rome, the capital city of Italy and the Lazio Region, has an estimated population of approximately 2.8 million, making it the most populous city in the country. The city is subdivided for administrative purposes into 15 municipalities. As of July 2024, the mean price of residential properties in Rome is 3,376 €/m², representing a 1.93% increase compared to July 2023 (3,312 €/m²). Over the past two years, the average price within the municipality of Rome reached its highest point in June 2024, at 3,395 €/m². The lowest recorded average price was in October 2023, with properties listed at an average of 3,306 €/m² (Immobiliare.it). The sample of comparables was selected from the ‘‘Prati’’ area, where, in July 2024, residential properties for sale were listed at an average price of 5,627 €/m². Property prices in the historic centre of Rome are considerably higher, with an average price of 7,918 €/m². Figure 1 provides a general overview of the average property values for the residential segment in the city of Rome (Immobiliare.it).

The ‘‘Prati’’ area represents a specific submarket within the broader urban context of the city of Rome, characterized by homogeneous extrinsic factors such as urban centrality, consolidated infrastructure, high historical and architectural value, and a stable socio-economic profile. These external characteristics contribute to defining a relatively uniform market environment, thereby ensuring that the observed differences in property values can be primarily attributed to intrinsic variables.

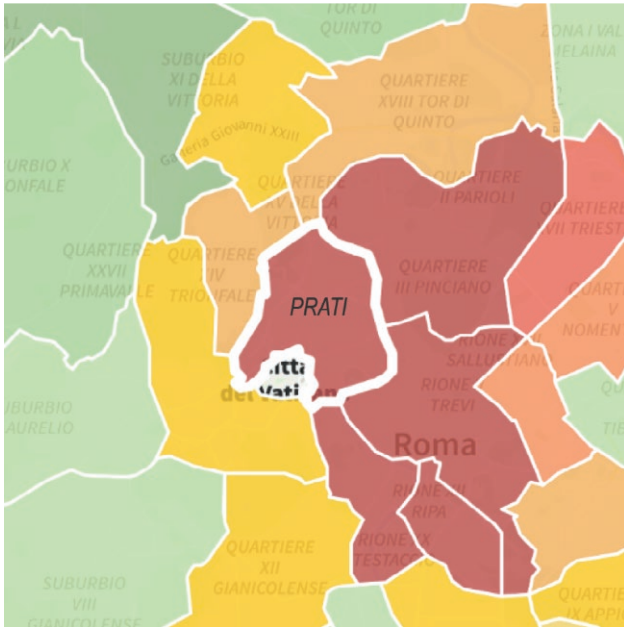


Figure 1. Average real estate values for the residential segment of Rome, with the “Prati” area delimited by a thick line (Immobiliare.it).

5.2. Data specification

The case study is based on a sample of five apartments, all situated within a homogeneous area in terms of quality and availability of essential services. Each property features an elevator, comprises at least five rooms, and falls within the same building category, specifically multi-story condominiums. Notably, only non-homogeneous property characteristics have been observed among the sampled units, as detailed in Table 2.

- Unit selling price (*P*), in Euros per square meter of floor area of the recently traded property.
- Floor Level (*F. lev.*): Represented as an ordinal categorical variable ranging from the first to the fifth floor.
- Number of Bathrooms (*Bath*): This variable indicates the actual count of bathroom facilities present in the residence, categorized similarly to the floor levels.

Table 2. Property dataset.

Unit selling price and characteristics	A	B	C	D	E
P [€/m ²]	6,312.06	6,533.33	4,600.00	6,428.57	7,500.00
F. Lev. [n°]	2	5	1	3	2
Bath [n°]	2	2	1	1	3
Maint [Score]	1	1	1	2	2

- Condition of preservation and maintenance (*Maint*): This qualitative variable is classified into three categories with a summary evaluation: “Good/Usable” (Score “1”), “Very good/Refurbished” (Score “2”), and “Excellent/New” (Score “3”).

Other property factors that exhibit uniformity across all sampled units have been excluded from the analysis.

Table 2 presents the collected data for the sample case, while Table 3 summarizes the key descriptive statistics. The average sale price for the sample is 6,275 €/m². The mean number of floors is 2.6. Only one property (B) in the sample features three bathrooms. Among the analyzed properties, three are classified as usable, two have been refurbished, and none are newly constructed.

5.3. Application of the SGA

In accordance with the data presented in Table 2, the SGA has been employed for each property within the sample under analysis. In this phase, each property has been individually evaluated, with other properties treated as comparables, following the methodological principles of the SGA. The application of the SGA is not merely concerned with determining the overall market value of the subject property (see Table 4), this approach also allows for the determination of implicit prices associated with the relevant property factors, which serve as the foundation for the comparative analysis. The results on these implicit prices are presented in Table 5.

From Table 4, it can be observed that the application of the SGA reveals significant discrepancies between the estimated values and the actual sale prices. The estimated

Table 3. Statistical description of the property dataset.

Index	Mean	Std. Error	Median	Std. Deviation	Asimm.	Min	Max
P [€/m ²]	6,274.79	468.93	6,428.57	1,048.56	-1.03	4,600.00	7,500.00
F. Lev. [n°]	2.60	0.68	2.00	1.52	1.12	1.00	5.00
Bath [n°]	1.80	0.37	2.00	0.84	0.51	1.00	3.00
Maint [Score]	1.40	0.24	1.00	0.55	0.61	1.00	2.00

Table 4. Results of the SGA.

Subject	Estimated Values [€]		Divergence between estimated values and detected prices SGA [%]
	SGA	Selling prices	
A	5,601.59	6,312.06	11.26
B	9,841.08	6,533.33	32.62
C	5,665.70	4,600.00	23.17
D	4,297.16	6,428.57	33.16
E	9,631.42	7,500.00	28.42

Table 5. SGA implicit prices of the influencing factors.

Implicit prices	A	B	C	D	E
F. Lev [€/n°]	310.58	784.23	73.76	73.76	73.76
Bath [€/n°]	691.01	927.83	572.59	1,638.30	1,638.30
Maint. [€/Score]	1,207.41	260.11	615.35	-450.35	1,681.06

value for Comparable A (5,601.59 €/m²) underestimates the sale price (6,312.06 €/m²) by 11.26%. The greatest divergence is observed for Comparable D, with a discrepancy of 33.16%, reflecting a substantially lower estimate compared to the effective price. Furthermore, notable discrepancies are evident in the case of Comparables B, C, and E, with deviations that are respectively equal to 32.62%, 23.17% and 28.42%. These findings suggest that the SGA method tends to either overestimate or underestimate the actual market values significantly.

Table 5 shows that the implicit prices for the floor level (*F. Lev*) are identical for Comparables C, D, and E (73.76 €/m²), whereas similar values are noted for the number of bathrooms (*Bath*) in Comparables D and E (1,638.30 €/m²). This uniformity points out limited empirical evidence of the SGA model in differentiating the effects of these factors, indicating potential distortions in the estimates of implicit contributions. The negative implicit price associated with the maintenance condition for Comparable D (-450.35 €/m²) is particularly noteworthy, an intuitive result that suggests a negative perception of maintenance improvements. This anomaly may arise from adverse interactions among characteristics or limitations of the model in accurately capturing the value of qualitative improvements, highlighting a potential bias in the SGA evaluations.

5.4. Application of the OWASM

The implementation of the OWASM begins with an initial phase that involves evaluating empirical con-

Table 6. Results of the OWASM.

Subject	Estimated Values [€]		Divergence between estimated values and detected prices OWASM [%]
	OWASM	Selling prices	
A	5,677.21	6,312.06	10.06
B	6,473.63	6,533.33	0.91
C	5,840.88	4,600.00	26.98
D	6,407.53	6,428.57	0.33
E	6,758.12	7,500.00	9.89

Table 7. OWASM implicit prices of the influencing factors.

Implicit prices	A	B	C	D	E
F. Lev [€]	394.56	76.67	165.72	115.83	87.00
Bath [€]	62.98	385.68	267.99	363.26	229.85
Maint [€]	974.35	471.56	322.74	406.04	306.62

straints, specifically concerning the anticipated signs of the implicit prices associated with the selected influencing factors. Considering widely acknowledged empirical phenomena, the algorithm outlined incorporates the following empirical constraints, Equation (26):

$$\begin{cases} P_{F. Lev} \geq 0 \\ P_{Bath} \geq 0 \\ P_{Maint} \geq 0 \end{cases} \quad (26)$$

Table 6 presents the results of the market value estimations for each property in the data sample. The outputs generated by the OWASM have been compared with the actual selling prices. The OWASM demonstrates a superior alignment with actual sale prices compared to the SGA, exhibiting generally smaller discrepancies. For Comparable A, the estimated value (5,677.21 €/m²) deviates by 10.06% from the actual price, while the lowest discrepancy is observed for Comparable D (0.33%), indicating an excellent predictive capability of the method in this instance. Other discrepancies remain modest, with Comparable B showing a minimal deviation of 0.91%, and Comparables C and E exhibiting deviations of 26.98% and 9.89%, respectively.

Table 7 presents the implicit prices of various features for each subject property in the data sample, derived through the implementation of the OWASM. The resulting outputs enhance the empirical reliability of the developed model. Regarding the floor level factor, the implicit price is less than €100 for only two (Properties B and E) of the five properties in the sample. These varying values could be reasonably attributed to specif-

ic market conditions and property characteristics that deviate from typical market behaviour. For example, factors such as frequent elevator malfunctions, excessive sunlight exposure on upper floors, inadequate thermal insulation on top floors, or the absence of balconies in upper levels may all contribute to this discrepancy. The bathroom factor is associated with an implicit price exceeding 200 € for four properties in the data sample (Properties B, C, D, and E), whereas it has a relatively minor influence on the valuation of Property E, with an implicit price of only 62.98 €. The condition of preservation and maintenance factor holds a substantial implicit price for Property A, amounting to 974.35 €/m², highlighting the property's need for renovation.

5.5. Application of the MAXENT

All computations have been carried out using MATLAB software version 9.0.0 (The MathWorks Inc.). For each subject, both the solution and the optimal value of the objective function have been calculated, along with the corresponding weights for each optimal solu-

tion (see Tables 8–12). Generally, to derive the predicted probabilities for a particular observation, the optimal weights obtained through the optimization process can be applied to the prediction function, ensuring accurate estimations. It is essential to emphasise that the present analysis has concentrated exclusively on the characteristics of “Maint” and “F. lev.” This focus is a consequence

Table 8. Solutions for comparable A (if considered as subject).

Comparable	Optimal Solution	Comparable Sale Price [€]	Contribution to the Estimated Value [€]
B	0.1875	6,533.00	1,224.94
C	0.3125	4,600.00	1,437.50
D	0.5000	6,428.00	3,214.00
E	0.0000	7,500.00	0.00
Estimated Value for Comparable [€]			5,876.44
Sale price detected for Comparable A [€]			6,312.00
% of divergence between sale price detected and estimated value for Comparable A [%]			6.90

Table 9. Solutions for comparable B (if considered as subject).

Comparable	Optimal Solution	Comparable Sale Price [€]	Contribution to the Estimated Value [€]
A	0.0000	6,312.00	0.00
C	0.5000	4,600.00	2,300.00
D	0.5000	6,428.00	3,214.00
E	0.0000	7,500.00	0.00
Estimated Value for Comparable [€]			5,514.00
Sale price detected for Comparable B [€]			6,533.00
% of divergence between sale price detected and estimated value for Comparable B [%]			15.60

Table 10. Solutions for comparable C (if considered as subject).

Comparable	Optimal Solution	Comparable Sale Price [€]	Contribution to the Estimated Value [€]
A	0.3333	6,312.00	2,103.79
B	0.1667	6,533.00	1,089.05
D	0.5000	6,428.00	3,214.00
E	0.0000	7,500.00	0.00
Estimated Value for Comparable [€]			6,406.84
Sale price detected for Comparable C [€]			4,600.00
% of divergence between sale price detected and estimated value for Comparable C [%]			39.28

Table 11. Solutions for comparable D (if considered as subject).

Comparable	Optimal Solution	Comparable Sale Price [€]	Contribution to the Estimated Value [€]
A	0.0000	6,312.00	0.00
B	0.3125	6,533.00	2,041.56
C	0.4375	4,600.00	2,012.50
E	0.2500	7,500.00	1,875.00
Estimated Value for Comparable [€]			5,929.06
Sale price detected for Comparable D [€]			6,428.57
% of divergence between sale price detected and estimated value for Comparable D [%]			7.77

Table 12. Solutions for comparable E (if considered as subject).

Comparable	Optimal Solution	Comparable Sale Price [€]	Contribution to the Estimated Value [€]
A	0.0000	6,312.00	0.00
B	0.3125	6,533.00	2,041.56
C	0.4375	4,600.00	2,012.50
D	0.2500	6,428.00	1,607.00
Estimated Value for Comparable [€]			5,661.06
Sale price detected for Comparable E [€]			7,500.00
% of divergence between sale price detected and estimated value for Comparable E [%]			24.52

of the MAXENT method, which further constrains the number of explanatory variables by reducing them to $(m-2)$, where m is the total number of comparables. Consequently, only the most influential factors are retained.

The MAXENT method exhibits significant variability in the estimated sale values, with discrepancies ranging from 6.90% to 39.28%. The most accurate result is observed for Comparable A, where the estimate (5,876.44 €/m²) deviates by only 6.90% from the actual price, demonstrating strong predictive capability in this instance. However, for Comparables C and E, the MAXENT considerably overestimates market values, with deviations of 39.28% and 24.5%, respectively. For Comparable D, the discrepancy is moderate at 7.77%, while Comparable B shows an underestimation of 15.60%. These results suggest that, despite some discrepancies, the MAXENT provides a relatively strong performance compared to the SGA and OWAS methods.

6. DISCUSSIONS

A comparison of the three methods (SGA, OWASM, and MAXENT) reveals some discrepancies in their predictive capabilities relative to observed market prices. Table 13 summarizes the results obtained in terms of market values estimated for each property in the sample. The results of the OWASM and the MAXENT have been compared with the original sales prices, and the same comparison has been reported for the SGA. Due to the

heterogeneity of the sample analyzed, the SGA method has generated outputs characterized by the highest average error, equal to 25.72%. The MAXENT application has provided more accurate estimates than the SGA, the divergences between detected prices and estimated values vary between 6.9% (Comparable A) and 39.3% (Comparable C), with an average prediction error equal to 18.81%. For the considered case study, the OWASM has demonstrated the best performance overall, with an average error of 9.63%, a maximum error of 26.98% (Comparable C), and a minimum error of about 0.3% (Comparable D).

Looking more closely at the individual subjects, it is evident that for Comparable A the MAXENT is the most efficient method, with a deviation of 6.90%, compared to 11.26% for SGA, which ranks lowest in terms of performance. For Comparable B, the most accurate estimation is provided by the OWASM, with a minimal divergence of 0.91%; once again, the SGA performs worst, with a deviation of 32.62%. Interestingly, for Comparable C – where the SGA had thus far underperformed – it yields the most accurate estimate, with a deviation of 23.17%, followed by the OWASM with a very close percentage (26.98%) and the MAXENT (39.28%). In the case of Comparable D, the OWASM again achieves the best result, with an error of just 0.33%, whereas the SGA registers the poorest performance, with a 33.16% deviation. For Comparable E, the OWASM proves once more to be the most reliable, with a deviation of 9.89%, while the SGA continues to underperform, reaching a divergence of 28.48%.

Table 13. Results of the SGA, the OWASM and the MAXENT.

Sub.	Comp.	Sale price detected [€/m ²]	SGA			OWASM			MAXENT	
			Estimated value [€]	Divergence [%]		Estimated value [€]	Divergence [%]		Estimated value [€]	Divergence [%]
A	B-C-D-E	6,312.06	5,601.59	11.26	5,677.21	10.06	5,876.44	6.90		
B	A-C-D-E	6,533.33	9,841.08	32.62	6,473.63	0.91	5,514.00	15.60		
C	A-B-D-E	4,600.00	5,665.70	23.17	5,840.88	26.98	6,406.84	39.28		
D	A-B-C-E	6,428.57	4,297.16	33.16	6,407.53	0.33	5,929.06	7.77		
E	A-B-C-D	7,500.00	9,631.42	28.42	6,758.12	9.89	5,661.06	24.52		
Mean absolute error [%]			25.72			9.63			18.81	
Explanatory factors needed (for comparable m)			m-1			m-1			m-2	
Implicit prices assessment			Yes			Yes			No	
			F. Lev	Bath	Maint	F. Lev	Bath	Maint		
A			311 €	691 €	1,207 €	395 €	63 €	974 €		
B			784 €	928 €	260 €	77 €	386 €	472 €		
C			74 €	573 €	615 €	166 €	268 €	323 €		
D			74 €	1,638 €	-450 €	116 €	363 €	406 €		
E			74 €	1,638 €	1,681 €	87 €	230 €	307 €		

Furthermore, the possibility to endogenously evaluate the implicit prices of the explanatory factors with a high empirical reliability constitutes another relevant advantage of the OWASM. This allows for the avoidance of subjectivity in determining the weights of the selected variables by the appraiser and can achieve accurate results using a limited set of comparable data. Although the implicit prices assessment represents an output of the SGA too, this method is characterized by a considerable instability in the resolution of the equation system in the presence of potential anomalies/outliers, which has a direct impact on the estimation of the implicit prices of the property characteristics being compared. On the other hand, the MAXENT does not allow inferring implicit prices of the property factors but it demonstrates considerable stability from a computational perspective.

Finally, it should be highlighted that, for the implementation of each method considered, named m the total number of comparables, the SGA and the OWASM need $m-1$ explanatory factors, whereas the MAXENT reduces the number of explanatory factors ($m-2$), in order to achieve a more streamlined and focused model. Furthermore, it should be pointed out that all three methods are not subject to operational limitations in the presence of qualitative variables too.

7. CONCLUSIONS

The economic and financial developments of recent years have significantly driven the revision of real estate valuation theories and techniques. Both in academia, where new approaches to value creation have emerged, and in practice, often characterized by ambiguity and approximation, the limitations of traditional methods have become evident. It is not uncommon for two expert appraisers to produce divergent market values for the same property, raising concerns about the precision and reliability of valuations. As a result, the accuracy of real estate valuations has become a critical priority for market participants, investors, and professionals, particularly in contexts where real estate data are scarce, and markets are opaque. In such scenarios, the collection of limited real estate data samples necessitates the optimal selection of comparable properties, as this choice significantly impacts the accuracy of the valuation. Furthermore, the increasing complexity of the factors influencing property values asks for more advanced approach methods that combine scientific rigor with user-friendliness, even for less experienced users. In this context, the present research examines the potentialities and the limits of three market approach methods, in order to pro-

vide for an improvement of the assessment reliability of professional valuers' reports, overcoming the limitations of traditional methods in the adjustments considered for the implicit prices, and addressing the challenges associated with the use of econometric techniques in contexts characterized by a high market dynamicity. In particular, as the SGA is often applied in practice, the OWASM and the MAXENT represent two innovative methods that occupy a middle ground between traditional property evaluation techniques and advanced statistical tools, exemplified by the most modern econometric methods.

Among the three methods analyzed, for the specific case study, the OWASM and the MAXENT have shown a high statistical performance (outlined by the reduced discrepancy between estimated and observed prices). Furthermore, the assessment of the implicit prices of the explanatory factors, provided by the OWASM, has pointed out the empirical reliability of the obtained outputs. Therefore, the proposed methods (in particular, the OWASM and the MAXENT) can constitute an integration to the canonical market-oriented methods for ordinary properties (e.g. residential units, offices, shops, etc.) and income approach methods, as the Discounted Cash Flow Analysis generally applied for special properties (e.g. hotels, nursing homes, cinemas, retail spaces, etc.), so as to provide additional tools to verify the results obtained.

Further insights will concern the comparison of the methods applied in other territorial contexts, by considering different intended uses and verifying their effectiveness in the presence of limited data or highly heterogeneous property factors. Furthermore, methodological refinement may be achieved through the integration of spatial econometric components and/or machine learning tools, with the objective of enhancing model adaptability and generalisation. Another promising direction involves the development of user-friendly software interfaces to facilitate the operational use of the methods OWASM and MAXENT, thus bridging the gap between methodological innovation and daily professional application.

NOTE

The paper is to be attributed in equal parts to the authors.

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Rassegna giurisprudenziale II semestre 2025

A CURA DI NICOLA LUCIFERO

AGRICOLTURA E PESCA

Corte giustizia Unione Europea, Sez. VII, Sentenza, 11/12/2025, C-497/24, *GC contro Regione Marche*

Rinvio pregiudiziale – Agricoltura – Politica agricola comune – Regolamento (UE) n. 1308/2013 – Programma di sostegno nel settore vitivinicolo – Finanziamento – Articolo 50 – Contributo dell’Unione europea – Calcolo dell’intensità massima di aiuto – Inclusione di un credito d’imposta previsto dalla normativa nazionale.

L’articolo 50, paragrafo 4, lettera b), del regolamento (UE) n. 1308/2013 del Parlamento europeo e del Consiglio, del 17 dicembre 2013, recante organizzazione comune dei mercati dei prodotti agricoli e che abroga i regolamenti (CEE) n. 922/72, (CEE) n. 234/79, (CE) n. 1037/2001 e (CE) n. 1234/2007 del Consiglio, deve essere interpretato nel senso che, ai fini del calcolo dell’intensità massima di aiuto per gli investimenti prevista da tale disposizione, occorre computare l’aiuto dell’Unione europea erogato a un beneficiario per un progetto di investimento, ma non il vantaggio che il medesimo beneficiario trae da un credito d’imposta previsto da una normativa nazionale.

Corte giustizia Unione Europea, Sez. VIII, Sentenza, 11/12/2025, n. 473/24, *Speyer & Grund GmbH & Co. KG contro Werner & Mertz GmbH*.

Rinvio pregiudiziale – Regolamento (UE) n. 528/2012 – Articolo 3, paragrafo 1, lettera a) – Nozione di “biocida” – Condizione relativa alla “destinazione” del prodotto – Prodotti a base di aceto destinati ad essere utilizzati sia come alimenti sia come prodotti per la pulizia/disinfettanti di tali alimenti (“prodotti multiuso”) – Ambito di applicazione del regolamento n. 528/2012 – Articolo 2, paragrafi 1 e 2 – Allegato V – Elenco dei tipi di biocidi contemplati dal regolamento – Tutela della salute umana e animale e dell’ambiente.

1) L’articolo 3, paragrafo 1, lettera a), primo trattino, del regolamento (UE) n. 528/2012 del Parlamento europeo e del Consiglio, del 22 maggio 2012, relativo alla messa a disposizione sul mercato e all’uso dei biocidi, come modificato dal regolamento (UE) n. 334/2014 del Parlamento europeo e del Consiglio, dell’11 marzo 2014, e dal regolamento delegato (UE) 2019/1819 della Commissione, dell’8 agosto 2019, deve essere interpretato nel senso che affinché rientri nella nozione di «biocida», come definita in tale disposizione, un prodotto non deve necessariamente essere destinato esclusivamente o principal-

mente a una finalità biocida, e che tale finalità può essere accessoria rispetto ad altre finalità.

2) L'articolo 2, paragrafi 1 e 2, del regolamento n. 528/2012, come modificato dal regolamento n. 334/2014 e dal regolamento delegato 2019/1819, in combinato disposto con l'allegato V, gruppo 1, tipo di prodotto 4, a tale regolamento, deve essere interpretato nel senso che un biocida destinato alla pulizia e alla disinfezione degli alimenti non rientra nell'ambito di applicazione di detto regolamento.

Cass. civ., Sez. I, Ordinanza, 05/08/2025, n. 22626

Epidemia epizootica – alta contagiosità – precauzione - misure contenimento – aumento di tutela - legittimità

In presenza di un'epidemia ad elevata contagiosità, come quella dell'afta epizootica, lo Stato membro può adottare misure protettive ulteriori e più restrittive rispetto a quelle comunitarie, purché tali misure siano necessarie e proporzionate al rischio e conformi ai principi di precauzione e proporzionalità tracciati dal diritto europeo.

T.A.R. Venezia, (Veneto) sez. IV, 13/10/2025, n.1775

Impianti fotovoltaici – idoneità – zone agricole di pregio – esclusione – presunzione semplice – prova contraria

I divieti del Comune violano l'art. 20, commi 1, 6 e 8, del d.lgs. 199/2021, in quanto introducono un regime discriminatorio per le aree agricole di pregio, escludendo in modo generalizzato gli impianti fotovoltaici, anche quelli agrivoltaici, che invece la L.R. Veneto n. 17/2022 riconosce come compatibili con l'uso agricolo in quanto riducono il consumo di suolo e mantengono la coltivazione. L.R. Veneto n. 17/2022 non vieta in modo assoluto gli impianti FER nelle aree agricole di pregio, ma introduce solo una presunzione relativa di non idoneità, superabile con valutazioni caso per caso. Mentre il Comune ha imposto i divieti senza motivazione né istruttoria, ignorando la natura agrivoltaica dei progetti, compatibili con l'attività agricola e il minor consumo di suolo. Di conseguenza, i divieti sono dichiarati illegittimi e annullati, con riconoscimento del silenzio-assenso sui titoli abilitativi degli impianti.

ALIMENTI E BEVANDE

Corte giustizia Unione Europea, Sez. VII, Sentenza, 13/11/2025, C-563/24, *Verband Sozialer Wettbewerb eV contro PB Vi Goods GmbH*

Rinvio pregiudiziale – Definizione, designazione, presentazione, etichettatura e protezione delle bevande

de spiritose – Regolamento (UE) 2019/787 – Articolo 10, paragrafo 7 – Divieto di utilizzare denominazioni legali per qualsiasi bevanda che non soddisfa i requisiti della pertinente categoria – Gin – Bevanda denominata “gin non alcolico” – Articolo 12, paragrafo 1 – Allusioni – Validità dell'articolo 10, paragrafo 7 – Articolo 16 della Carta dei diritti fondamentali dell'Unione europea – Libertà d'impresa – Principio di proporzionalità.

L'articolo 10, paragrafo 7, del regolamento (UE) 2019/787 del Parlamento europeo e del Consiglio, del 17 aprile 2019, relativo alla definizione, alla designazione, alla presentazione e all'etichettatura delle bevande spiritose, all'uso delle denominazioni di bevande spiritose nella presentazione e nell'etichettatura di altri prodotti alimentari, nonché alla protezione delle indicazioni geografiche delle bevande spiritose e all'uso dell'alcole etilico e di distillati di origine agricola nelle bevande alcoliche, e che abroga il regolamento (CE) n. 110/2008, come modificato dal regolamento delegato (UE) 2021/1096 della Commissione, del 21 aprile 2021, deve essere interpretato nel senso che esso vieta di utilizzare la denominazione “gin non alcolico” nella presentazione e nell'etichettatura di una bevanda analcolica per il motivo che tale bevanda non soddisfa i requisiti previsti al punto 20, lettere a) e b), dell'allegato I di tale regolamento per la categoria di bevande spiritose rispondenti alla denominazione legale di “gin”.

Corte giustizia Unione Europea, Sez. VIII, Sentenza, 09/10/2025, C-315/24, *Nestlé Sverige AB contro Miljönämnden i Helsingborgs kommun.*

Rinvio pregiudiziale – Sicurezza degli alimenti – Regolamento (UE) n. 1169/2011 – Informazioni ai consumatori sugli alimenti – Regolamento delegato (UE) 2016/128 – Alimenti a fini medici speciali – Prescrizioni specifiche in materia di informazione – Dichiarazione nutrizionale obbligatoria – Articolo 5, paragrafo 2, lettera g) – Indicazioni obbligatorie complementari – Articolo 6, paragrafo 2 – Divieto di ripetere nell'etichettatura le informazioni contenute nella dichiarazione nutrizionale obbligatoria».

L'articolo 5, paragrafo 2, lettera g), e l'articolo 6, paragrafo 2, del regolamento delegato (UE) 2016/128 della Commissione, del 25 settembre 2015, che integra il regolamento (UE) n. 609/2013 del Parlamento europeo e del Consiglio per quanto riguarda le prescrizioni specifiche in materia di composizione e di informazione per gli alimenti destinati a fini medici speciali, devono essere interpretati nel senso che l'indicazione, sulla parte anteriore dell'imballaggio di un alimento a fini medici speciali, del valore energetico e della quantità di diverse sostanze

ze nutritive, espressi per porzione o per unità di consumo – mentre la dichiarazione nutrizionale obbligatoria, figurante sulla parte posteriore di tale imballaggio, contiene l'indicazione di questi stessi elementi per 100 g o 100 ml – non costituisce una «descrizione delle proprietà e/o caratteristiche» di detto alimento, ai sensi dell'articolo 5, paragrafo 2, lettera g), di tale regolamento delegato, bensì una ripetizione delle informazioni contenute in tale dichiarazione nutrizionale obbligatoria, vietata dall'articolo 6, paragrafo 2, di detto regolamento delegato.

Corte giustizia Unione Europea, Sez. III, Sentenza, 11/09/2025, C-341/24, *Duca di Salaparuta SpA contro Ministero dell'Agricoltura, della Sovranità alimentare e delle Foreste*

Rinvio pregiudiziale – Agricoltura – Organizzazione comune del mercato vitivinicolo – Regime comunitario di protezione delle denominazioni dei vini – Regolamento (CE) n. 1493/1999 – Articolo 54 – Vini di qualità prodotti in regioni determinate (v.q.p.r.d.) – Regolamento (CE) n. 479/2008 – Articolo 43, paragrafo 2, e articolo 51 – Regolamento (CE) n. 1234/2007 – Articolo 118 duodecies, paragrafo 2, e articolo 118 vicies – Regolamento (UE) n. 1308/2013 – Articolo 101, paragrafo 2, e articolo 107 – Protezione, ai sensi del diritto dell'Unione, dei v.q.p.r.d. riconosciuti dal diritto nazionale – Conflitto tra una denominazione di vini protetta e un marchio anteriore notorio contenente un termine identico a tale denominazione – Denominazione asseritamente ingannevole – Regime transitorio – Estensione automatica della protezione – Completezza del regime di protezione – Certezza del diritto

L'articolo 51 del regolamento (CE) n. 479/2008 del Consiglio, del 29 aprile 2008, relativo all'organizzazione comune del mercato vitivinicolo, che modifica i regolamenti (CE) n. 1493/1999, (CE) n. 1782/2003, (CE) n. 1290/2005 e (CE) n. 3/2008 e abroga i regolamenti (CEE) n. 2392/86 e (CE) n. 1493/1999, l'articolo 118 vicies del regolamento (CE) n. 1234/2007 del Consiglio, del 22 ottobre 2007, recante organizzazione comune dei mercati agricoli e disposizioni specifiche per taluni prodotti agricoli (regolamento unico OCM), come modificato dal regolamento (CE) n. 491/2009 del Consiglio, del 25 maggio 2009, e l'articolo 107 del regolamento (UE) n. 1308/2013 del Parlamento europeo e del Consiglio, del 17 dicembre 2013, recante organizzazione comune dei mercati dei prodotti agricoli e che abroga i regolamenti (CEE) n. 922/72, (CEE) n. 234/79, (CE) n. 1037/2001 e (CE) n. 1234/2007 del Consiglio, devono essere interpretati nel senso che l'articolo 43, paragrafo 2, del regolamento n. 479/2008, l'articolo 118 duodecies del regolamento n. 1234/2007, come modificato dal regolamento n.

491/2009, e l'articolo 101, paragrafo 2, del regolamento n. 1308/2013 non sono applicabili a un conflitto tra una denominazione di vini protetta ai sensi dell'articolo 54 del regolamento (CE) n. 1493/1999 del Consiglio, del 17 maggio 1999, relativo all'organizzazione comune del mercato vitivinicolo, e marchi anteriori notori registrati per vini, contenenti termini identici a detta denominazione, dovendo tale conflitto essere risolto solo sulla base dell'allegato VII, sezione F, paragrafo 2, secondo comma, di quest'ultimo regolamento.

AMBIENTE

T.A.R. Liguria Genova, Sez. II, Sentenza, 10/11/2025, n. 1264

Rete Natura 2000 – VInCA – Rapporto con la VIA – competenza

La competenza ad effettuare la valutazione di incidenza ambientale (VINCA) è stabilita dagli artt. 8 e 9 della L.R. n. 28 del 2009, i quali attribuiscono tale competenza ai soggetti gestori dei siti rete Natura 2000, salvo i casi in cui progetti e interventi siano soggetti alla valutazione di impatto ambientale (VIA). In tali casi, la competenza per la VINCA spetta alla Regione solo se la procedura di VIA si è svolta pienamente fino al provvedimento “conclusivo” di VIA, eventualmente in virtù di un preliminare screening positivo di “assoggettabilità” a VIA ex art. 19, comma 8, D.Lgs. n. 152 del 2006.

T.A.R. Lombardia Brescia, Sez. I, Sentenza, 04/09/2025, n. 793

VInCA – natura – atto endoprocedimentale – efficacia lesiva - impugnazione con atto principale

I provvedimenti di Valutazione di Incidenza Ambientale (VInCA) sono atti endoprocedimentali e non autonomamente impugnabili. Essi devono essere impugnati unitamente al provvedimento autorizzatorio finale, in quanto privi di autonoma lesività in assenza delle successive autorizzazioni che su di essi si fondano (art. 35, comma 1, lett. b), c.p.a.).

CACCIA E PESCA

Cass. pen., Sez. III, Sentenza, 07/04/2025, n. 30584

Caccia - Abbattimento, cattura o detenzione di carrellini in numero superiore a cinque - Contravvenzione di cui all'art. 30, comma 1, lett. h), legge n. 157 del 1992 - Configurabilità - Ragioni - Contravvenzione di cui all'art. 727-bis cod. pen. - Concorso formale - Assistenza - Condizioni

L'abbattimento, la cattura o la detenzione di cardellini in numero superiore a cinque, appartenendo questi alla famiglia dei fringillidi, integra la contravvenzione di cui all'art. 30, comma 1, lett. h), legge 11 febbraio 1992, n. 157, che concorre con quella di uccisione, cattura o detenzione di esemplari di specie di animali selvatiche protette prevista dall'art. 727-bis cod. pen., in quanto tali volatili risultano contemplati nell'allegato I della direttiva 2009/147/CE, sempreché l'azione riguardi una quantità trascurabile di uccelli e abbia, pertanto, un impatto altrettanto trascurabile sullo stato di conservazione della specie.

CONTRATTI AGRARI

Cass. civ., Sez. III, Ordinanza, 15/10/2025, n. 27557

Compravendita – patto riservato dominio – competenza sezione specializzata - esclusione

La competenza delle Sezioni Specializzate Agrarie è esclusa quando il rapporto dedotto in giudizio riguarda la compravendita con patto di riservato dominio di un fondo rustico, poiché tale materia non implica l'applicazione delle norme sul rapporto agrario, che risulta solo un presupposto di fatto suscettibile di accertamento incidentale, senza che ciò comporti la competenza per materia dei rapporti agrari.

Cass. civ., Sez. III, Ordinanza, 02/08/2025, n. 22327

Contratti agrari - Controversie - Disposizioni processuali - Giudizio per morosità - Sanatoria - Domanda di risoluzione per morosità - Sanatoria ex art. 11, comma 8, d.lgs. n. 150 del 2011 - Interessi sui canoni insoluti - Misura legale ex art. 1284, comma 1, c.c. - Specifica domanda di pagamento dei canoni insoluti - Interessi ex art. 1284, comma 4, c.c. - Applicabilità

I) In tema di contratti agrari, la misura degli interessi da corrisondersi sui canoni scaduti da parte del conduttore, al fine di conseguire la sanatoria della morosità, è quella legale di cui all'art. 1284, comma 1, c.c., in virtù della disposizione speciale di cui all'art. 11, comma 8, d.lgs. n. 150 del 2011, trovando, invece, applicazione il saggio c.d. superlegale ex art. 1284, comma 4, c.c., laddove l'affittante, anche congiuntamente alla richiesta di risoluzione del contratto, formuli specifica domanda giudiziale di pagamento dei canoni suddetti.

II) Nel contratto di affitto agrario, la domanda di risoluzione fondata su una clausola risolutiva espressa non esclude l'operatività della sanatoria in giudizio della morosità ex art. 11, comma 8, del d.lgs. n. 150 del 2011, la cui formulazione generale ricomprende ogni ipotesi in cui venga dedotto l'inadempimento dell'obbligo di paga-

mento dei canoni e si attaglia, dunque, a qualsiasi azione di risoluzione del contratto.

Cass. civ., Sez. III, Ordinanza, 02/08/2025, n. 22322

Contratti agrari - Accordi tra le parti - Accordi in deroga alle norme vigenti - Validità - Presupposti - Necessaria assistenza delle organizzazioni sindacali - Requisiti

Ai fini della stipulazione di accordi in deroga alle norme vigenti in materia di contratti agrari, ai sensi dell'art. 45 della l. n. 203 del 1982, il requisito dell'assistenza dell'associazione professionale di categoria postula un'effettiva attività di consulenza e di indirizzo, che chiarisca alle parti il contenuto e lo scopo delle singole clausole contrattuali che si discostano dalle disposizioni di legge, affinché la stipulazione avvenga con la massima consapevolezza possibile, con la conseguenza che, ove l'assistenza sia stata prestata in tal modo, il contratto è valido, essendo a tal fine probante la sottoscrizione, da parte dei contraenti e dei loro rispettivi rappresentanti sindacali, del documento negoziale.

T.A.R. Puglia Lecce, Sez. III, Sentenza, 11/11/2025, n. 1499

Compravendita fondo rustico – risoluzione - trascrizione – opponibilità – contratti di affitto

Gli effetti esterni di una pronuncia giudiziale di risoluzione di un contratto di compravendita di un fondo rustico intercorso tra una pubblica amministrazione e un privato si producono solo a seguito della trascrizione della sentenza nei Registri Immobiliari. Tale trascrizione non annulla automaticamente contratti di affitto stipulati e registrati prima di essa.

Corte d'Appello Trento, Sez. I, Sentenza, 31/07/2025, n. 142

Contratto di affitto – esistenza – onere della prova – autodichiarazione indirizzata alla PA – esclusione.

La dimostrazione della sussistenza di un contratto di affitto agrario, quale presupposto per l'esercizio della prelazione e del riscatto agrario, non può fondarsi esclusivamente sulle dichiarazioni sostitutive di atto di notorietà ai sensi dell'art. 47 D.P.R. n. 445/2000, aventi valenza probatoria limitata ai rapporti con la Pubblica Amministrazione e prive di efficacia in sede giurisdizionale. È necessario fornire una prova diretta dell'accordo di affitto stipulato tra le parti.

Tribunale Catanzaro, Sez. agraria, Sentenza, 24/09/2025, n. 1939

Contratti agrari – affitto – disciplina applicabile – restituzione del fondo – ritardo – danno risarcibile – 1591 c.c.

L'articolo 1591 cod. civ. trova applicazione non solo alle locazioni di immobili urbani, ma anche ai contratti di affitto di fondi rustici. L'affittuario di fondo rustico in mora è tenuto a corrispondere il risarcimento del danno calcolato in via forfettaria rinviando al canone pattuito, per tutto il tempo in cui rimane nella detenzione del bene fino all'effettiva riconsegna.

CONSORZI

Cass. civ., Sez. V, Ordinanza, 13/12/2025, n. 32515

Consorzio – contributo – finalità – obbligo di correzione

L'obbligatorietà dei contributi consortili non viene meno per la carenza di specifiche opere di manutenzione nell'anno di riferimento, essendo connessa all'esistenza e alla funzionalità di impianti e manufatti per la difesa idraulica dei terreni inclusi nel comprensorio consortile. Il contributo consortile è giustificato dalla funzione continuativa di tutela e manutenzione del consorzio, che garantisce condizioni di stabilità del suolo e previene fenomeni di esondazione, a beneficio diretto e specifico degli immobili proteggibili dalla funzione stessa.

Cass. civ., Sez. V, Ordinanza, 13/12/2025, n. 32514

Consorzio – consorzio irriguo - contributo – quota - composizione

In tema di contributi consortili per il servizio irriguo, il presupposto impositivo è il beneficio fondiario derivante dalla disponibilità irrigua. È possibile distinguere una quota fissa e una quota variabile: la prima è dovuta indipendentemente dall'effettivo utilizzo del servizio ed è costituita dai costi per la potenzialità di quest'ultimo; la seconda è dovuta in relazione alla quantità di acqua concretamente utilizzata. Per entrambe le quote il presupposto impositivo del contributo dovuto è il beneficio fondiario derivante dalla disponibilità irrigua, con la differenza che, mentre per la quota fissa il contributo è dovuto indipendentemente dall'effettivo utilizzo, la quota variabile è dovuta in relazione al quantitativo di acqua effettivamente utilizzato.

Cons. Stato, Sez. III, Sentenza, 04/11/2025, n. 8575

DOP e IGP – Consorzi di tutela – opposizione - legittimazione ad agire

L'interesse concreto e attuale di un consorzio volontario di tutela di una denominazione di origine protetta (DOP) a contestare una riclassificazione di additivi alimentari sussiste quando tale attività potrebbe incidere sui comportamenti di consumo e sulla concorrenza nel mercato, soprattutto se i prodotti DOP rivali competono nello stesso segmento di mercato (art. 14 L. n. 526 del 1999; Regolamento (CE) n. 1151/2012).

IMPRESA E LAVORO

Tribunale Bologna, Sez. IV, 22/07/2025

Fondo rustico – affitto – proprietario – rendita – impresa agricola – gestione crisi

La locazione di fondi rustici, in assenza di attività agricole dirette, è idonea a confermare in capo all'affittante la qualità di impresa agricola, tale da renderla assoggettabile a liquidazione controllata, malgrado risulti che i ricavi siano in prevalenza ascrivibili ai redditi da locazione.

PROPRIETÀ E PRELAZIONE

Cass. civ., Sez. III, Ordinanza, 14/01/2026, n. 762

Prelazione – fatti non contestati – contestazione – onere della prova

In materia di prelazione e riscatto agrario, il principio di non contestazione ha rilievo soltanto quando i fatti controversi siano noti alla parte o quando siano conoscibili con l'ordinaria diligenza. La mera genericità della contestazione da parte di una delle parti processuali non esenta l'altra dal dover fornire adeguata prova dei requisiti soggettivi e oggettivi per l'esercizio del diritto di riscatto agrario.

Cass. civ., Sez. II, Ordinanza, 21/10/2025, n. 27959

Diritto di prelazione e di riscatto - Prelazione agraria ex art. 8, comma 3, l. n. 590 del 1965 - Previsione di pagamento di provvigione al mediatore previsto nel contratto preliminare di vendita del fondo oggetto di prelazione - Debenza - Esclusione - Fondamento - Mediazione - Provvigione -

Il coltivatore diretto che esercita il diritto di prelazione di cui all'art. 8, co. 3, legge 26-5-1965 n. 590, non è tenuto al pagamento della provvigione al mediatore, ancorché il pagamento della provvigione sia regolato dal contratto preliminare. Tale obbligo non può vincolare il soggetto che esercita il diritto di prelazione, sia perché il rapporto di mediazione rimane distinto rispetto alla compravendita, sia perché la relativa clausola si risolve nel comportare condizioni di pagamento più onerose rispetto a quelle legali.

Cass. civ., Sez. II, Ordinanza, 17/07/2025, n. 19802

Riforma fondiaria - Terreni soggetti a riforma - In genere - Terreni acquistati dagli enti di riforma fondiaria - Destinazione all'attuazione della funzione istituzionale di detti enti - Conseguenze - Modificazioni - Limiti - Usucapione da parte di terzi - Inammissibilità - Scadenza del termine per l'assegnazione delle terre - Irrilevanza – Fattispecie

I terreni acquistati dagli enti di riforma fondiaria, essendo destinati all'attuazione della funzione istituzionale di redistribuzione della proprietà terriera ai contadini (come stabilito dall'art. 1 della l. n. 230 del 1950) non possono, in quanto destinati a un pubblico servizio, essere sottratti a tale finalità se non nei modi stabiliti dalle leggi che li riguardano, ai sensi degli artt. 830, comma 2, e 828, comma 2, c.c., con conseguente impossibilità giuridica della loro acquisizione da parte di terzi per usucapione, ancorché sia venuto a scadenza il termine ordinatorio previsto dall'art. 20 della medesima l. n. 230 del 1950 per l'assegnazione delle terre acquisite. (Nella specie, la S.C. ha cassato la sentenza impugnata, che aveva riconosciuto l'usucapione di una servitù di passaggio su una striscia di terreno già appartenente al patrimonio della riforma fondiaria, destinata a funzione di fascia frangivento).

TRIBUTI, CONTRIBUTI E AGEVOLAZIONI

Corte giustizia Unione Europea, Sez. IX, Sentenza, 23/10/2025, C-466/24

Rinvio pregiudiziale – Agricoltura – Politica agricola comune (PAC) – Regolamento (UE) 2021/2115 – Sostegno ai piani strategici – Regolamento (UE) n. 1307/2013 – Pagamenti diretti agli agricoltori – Superfici a disposizione degli agricoltori – Titolo giuridico per l'utilizzo di tali superfici – Modalità di registrazione di tale titolo giuridico – Superfici dichiarate nell'ambito dei regimi di aiuto superiori a quelle di cui è stato registrato il titolo giuridico per l'utilizzo – Sanzioni amministrative applicabili in caso di sovradichiarazione di superfici – Sanzioni ai sensi dell'articolo 19 bis del regolamento (UE) n. 640/2014 – Articolo 19 bis – Sanzioni – Applicabilità di tale articolo dopo l'abrogazione del regolamento n. 640/2014

L'articolo 32, paragrafo 2, lettera a), e l'articolo 36, paragrafi 2 e 5, 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, devono essere interpretati nel senso che essi non ostano a una normativa nazionale o a una prassi nazionale in forza della quale a un agricoltore può essere negato il diritto al pagamento dell'aiuto per superfici per il cui utilizzo tale agricoltore ha concluso un contratto per l'anno in questione, qualora tale contratto, in quanto titolo giuridico per l'utilizzo di dette superfici, non sia stato registrato nella banca dati informatizzata

designata a tal fine ed entro i termini previsti dal diritto nazionale, purché siano rispettati gli obiettivi perseguiti dalla normativa dell'Unione di cui trattasi e i principi generali del diritto dell'Unione, in particolare i principi di proporzionalità e di certezza del diritto.

Corte giustizia Unione Europea, Sez. IX, Sentenza, 23/10/2025, C-267/24, *Kanevi Komers DS EOOD contro Zamestnik izpalnitelen direktor na Darzhaven fond «Zemedelie»*.

Rinvio pregiudiziale – Agricoltura – Politica agricola comune (PAC) – Regimi di sostegno diretto – Regolamento delegato (UE) n. 640/2014 – Articolo 15, paragrafo 1 – Deroche all'applicazione di sanzioni amministrative – Domanda di aiuto inesatta – Ritiro di una siffatta domanda – Notifica all'autorità nazionale competente – Sanzioni amministrative applicabili in caso di sovradichiarazione di superfici – Sanzioni ai sensi dell'articolo 19 bis del regolamento delegato n. 640/2014 – Applicabilità di tale articolo dopo l'abrogazione del regolamento delegato n. 640/2014.

1) L'articolo 15, paragrafo 1, 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, come modificato dal regolamento delegato (UE) n. 2016/1393 della Commissione, del 4 maggio 2016, deve essere interpretato nel senso che esso non osta a una normativa nazionale che obbliga il soggetto che richiede l'aiuto ad informare l'autorità nazionale competente di qualsiasi errore o modifica della domanda di aiuto o della domanda di pagamento unicamente mediante una piattaforma informatica dedicata, purché siano rispettati gli obiettivi perseguiti dalla normativa dell'Unione di cui trattasi e i principi generali del diritto dell'Unione, in particolare i principi di proporzionalità e di certezza del diritto.

2) L'articolo 15, paragrafo 1, del regolamento delegato n. 640/2014, come modificato dal regolamento delegato n. 2016/1393, deve essere interpretato nel senso che da un lato, l'applicazione di sanzioni amministrative in caso di domanda di aiuto o di domanda di pagamento inesatta postula che l'autorità nazionale competente dimostri che entrambe le condizioni ivi enunciate non sono soddisfatte, e ciò nel rispetto – fatti salvi i principi di equivalenza e di effettività – delle modalità di produzione della prova, delle condizioni di ricevibilità dei mezzi di prova o ancora dei principi che disciplinano la valutazione dell'effica-

cia probatoria degli elementi di prova nonché lo standard di prova richiesto fissati dal diritto nazionale e, dall'altro, tale disposizione consente a un beneficiario di modificare o di ritirare la sua domanda di aiuto o la sua domanda di pagamento finché non sia stato informato del fatto che l'autorità competente ha effettuato un controllo o ha riscontrato un'inadempienza nella sua domanda.

3) L'articolo 15, paragrafo 1, del regolamento delegato n. 640/2014, come modificato dal regolamento delegato n. 2016/1393, deve essere interpretato nel senso che esso osta, da un lato, ad una disposizione nazionale in forza della quale il soggetto che richiede il sostegno non può ritirare la sua domanda qualora sia stato oggetto di un controllo in loco e sia stato informato di inadempienze riscontrate, limitate alle sole superfici e/o agli animali oggetto della domanda, e, dall'altro, a una prassi dell'autorità nazionale competente in forza della quale il beneficiario dell'aiuto non viene informato del controllo in loco né del suo esito.. 640/2014 – Articolo 15, paragrafo 1 – Deroghe all'applicazione di sanzioni amministrative – Domanda di aiuto inesatta – Ritiro di una siffatta domanda – Notifica all'autorità nazionale competente – Sanzioni amministrative applicabili in caso di sovradichiarazione di superfici – Sanzioni ai sensi dell'articolo 19 bis del regolamento delegato n. 640/2014 – Applicabilità di tale articolo dopo l'abrogazione del regolamento delegato n. 640/2014.

Trib. I Grado Unione Europea, Sentenza, 22/10/2025, T-614/24, *AROCO, spol. s r. o. contro Generální ředitelství cel*.

Rinvio pregiudiziale – Armonizzazione delle normative fiscali – Direttiva 92/83/CEE – Armonizzazione delle strutture delle accise sull'alcole e sulle bevande alcoliche – Accise – Alcol etilico – Esenzioni – Articolo 27, paragrafo 1, lettera e) – Produzione di aromi con impiego di alcol etilico destinati alla preparazione di prodotti alimentari e di bevande analcoliche aventi titolo alcolometrico effettivo non superiore all'1,2% in volume – Facoltà degli Stati membri di subordinare a condizioni tali esenzioni

L'articolo 27, paragrafo 1, lettera e), della direttiva 92/83/CEE del Consiglio, del 19 ottobre 1992, relativa all'armonizzazione delle strutture delle accise sull'alcole e sulle bevande alcoliche, deve essere interpretato nel senso che un'esenzione dall'accisa sull'alcol etilico contenuto negli aromi catalogati sotto la voce 3302 10 della nomenclatura combinata non può essere subordinata alla prova dell'effettivo impiego di tali aromi per la preparazione di prodotti alimentari e di bevande analcoliche aventi titolo alcolometrico non superiore all'1,2% in volume, ma deve essere basata sulla loro destinazione a tale uso.

Corte di giustizia tributaria di secondo grado Lazio, Sez. IV, Sentenza, 16/10/2025, n. 6239

Cooperative – natura mutualistica - contributo AGCM – obbligo debenza

Le società cooperative agricole sono assoggettate al contributo al finanziamento dell'Autorità Garante della Concorrenza e del Mercato (AGCM), previsto dai commi 7 ter e 7 quater dell'art. 10 della L. n. 287 del 1990, indipendentemente dalla natura mutualistica o speculativa della società. Il parametro del fatturato oltre una certa soglia è inteso in senso ampio e sostanziale quale indicatore della capacità dell'impresa di incidere sui contesti di mercato, legittimando la contribuzione ai fini della tutela della concorrenza.

Cons. Stato, Sez. VI, Sentenza, 25/09/2025, n. 7539

PAC – Aiuti – requisiti – coltivazione – titolo idoneo – autocertificazione - esclusione

Per avere accesso agli aiuti comunitari nel settore agricolo, è necessario non solo la materiale coltivazione dei fondi dichiarati, ma anche il possesso di validi titoli di conduzione dei terreni. La mancata produzione di documentazione attestante la legittima conduzione dei terreni nella domanda di aiuti, nonostante l'autocertificazione, non soddisfa i requisiti normativi previsti dal D.P.R. n. 503 del 1999.

Cons. Stato, Sez. VI, Sentenza, 07/07/2025, n. 5881

PAC – sviluppo rurale – aiuti – zone montane – individuazione - regioni

In materia di individuazione delle zone montane ai fini dell'erogazione di aiuti agricoli previsti dal Reg. UE n. 1305/2013, spetta alle regioni italiane, competenti in materia di agricoltura, svolgere una specifica istruttoria sulle caratteristiche geofisiche delle superfici interessate e delle aziende agricole operanti in tali zone, anche quando non sono classificate totalmente montane secondo i criteri ISTAT.

T.A.R. Campania Napoli, Sez. III, Sentenza, 02/10/2025, n. 6536

Agevolazioni – erogazioni indebite – recupero - competenza

Nel contesto della Politica Agricola Comune (PAC), il regolamento (UE) n. 1306/2013 conferisce agli Stati membri, e in particolare per l'Italia all'AGEA, la competenza di recuperare i contributi indebitamente erogati. Tale competenza è una deroga specifica alla norma generale del regolamento (CE) n. 659/1999, che affida alla Commissione europea la "decisione di recupero" degli aiuti.

T.A.R. Campania Napoli, Sez. III, Sentenza, 22/09/2025, n. 6266

PAC – sviluppo rurale – aree soggette a vincoli – individuazione - criteri

La delimitazione delle aree soggette a vincoli naturali significativi secondo il Regolamento UE 1305/2013, richiede un'analisi bifasica che comprende sia i parametri biofisici sia quelli economici (fine tuning). La Regione Campania, nell'applicazione delle tabelle del PSR, ha correttamente utilizzato i criteri stabiliti dal Decreto Ministeriale n. 6277/2020 e dalla normativa comunitaria, escludendo i comuni non conformi ai vincoli.

Cass. civ., Sez. V, Ordinanza, 01/09/2025, n. 24339

Controlli ufficiali – mangimi e alimenti – tariffa – determinazione forfettaria – proporzionalità e ragionevolezza – soggetto passivo

La determinazione forfettaria della tariffa sui controlli ufficiali sanitari di mangimi e alimenti deve tenere conto delle specifiche caratteristiche imprenditoriali del soggetto passivo, conforme ai principi di ragionevolezza e proporzionalità stabiliti dalla normativa comunitaria.

Cass. civ., Sez. I, Ordinanza, 05/08/2025, n. 22689

AGEA – controlli – autorizzazione regionale – non esclusione dei controlli

In tema di contributi comunitari per programmi operativi nel settore agricolo, l'AGEA, quale ente deputato all'erogazione e ai controlli, ha il potere di verificare la rispondenza e conformità delle modifiche apportate ai programmi operativi anche se queste sono state autorizzate dalle Regioni. Pertanto, la mera presenza di autorizzazioni regionali non può valere a precludere il controllo successivo da parte di AGEA e non legittima automaticamente la percezione dei contributi comunitari, che devono rispettare sostanzialmente le condizioni stabilite dal regolamento comunitario applicabile.

Cass. civ., Sez. I, Sentenza, 05/08/2025, n. 22586

PAC – contributi – scissione – interpretazione estensiva - rapporto con diritto societario - esclusione

La nozione di "scissione" ai fini dell'assegnazione definitiva dei titoli PAC può essere interpretata in senso estensivo, comprendendo operazioni giuridiche che comportano il trasferimento di superfici agricole, anche ove tali operazioni non corrispondano alla scissione secondo il diritto societario. Gli aiuti comunitari devono essere proporzionalmente attribuiti agli agricoltori che, nel periodo di riferimento, gestiscono le superfici agricole originarie.

Cassazione civile sez. trib., 04/07/2025, n.18210

Quote di produzione – cessione – assoggettabilità IVA

La cessione di "quote di produzione" di prodotti agricoli avente ad oggetto il diritto di coltivazione di un determinato prodotto (nella specie tabacco), configurandosi come prestazione di servizi strumentali alla cura ed allo sviluppo del ciclo biologico della coltura, è soggetta al regime ordinario dell'IVA, anche quando la cessione sia effettuata da un'associazione di produttori per conto dei propri associati, stante il disposto di cui all'art. 4, comma 2, D.P.R. n. 633 del 1972, vigendo il principio di assoggettamento ad IVA delle operazioni relative a prestazioni di servizi rese dalle associazioni".

USI CIVICI

Corte cost., 24/07/2025, n. 125

Usi civici - Tutela - Affidamento al Commissario per la liquidazione degli usi civici del potere di iniziare d'ufficio i procedimenti giudiziari che egli stesso dovrà decidere (nel caso di specie: usi civici ritenuti appartenere alla proprietà collettiva dei naturali di Anagni) - Denunciata violazione del diritto di difesa e dei principi di terzietà e imparzialità del giudice, nonché del principio, anche convenzionale, del giusto processo - Inammissibilità delle questioni - Necessità di un intervento legislativo.

Sono inammissibili le questioni di legittimità costituzionale sollevate - in riferimento agli artt. 24, 111 e 117 Cost., quest'ultimo in relazione all'art. 6 CEDU e all'art. 47 CDFUE - dell'art. 29, comma 2, della legge n. 1766 del 1927, nella parte in cui, a seguito della declaratoria di illegittimità costituzionale da parte della Corte con la sentenza n. 46 del 1995, avrebbe consentito al commissario agli usi civici di avviare d'ufficio i procedimenti giudiziari ch'egli stesso avrebbe dovuto successivamente definire, poiché si tratta di opzioni che vanno ascritte al legislatore, non ravvisandosi una soluzione costituzionalmente compatibile che assicuri, allo stesso tempo, l'adeguata tutela del bene-ambiente e la corretta articolazione delle funzioni giurisdizionali.

Cass. civ., Sez. Unite, Ordinanza, 26/11/2025, n. 31005

Usi civici – liquidazione – giurisdizione Commissario regionale – *qualitas soli*

La giurisdizione del Commissario regionale per la liquidazione degli usi civici, prevista dall'art. 29 della L. n. 1766 del 1927, sussiste ogniqualvolta l'accertamento della *qualitas soli*, e quindi la soluzione delle questioni relative all'esistenza, natura ed estensione dei diritti di uso

civico, nonché alla qualità demaniale del suolo, si ponga come antecedente logico-giuridico della decisione.

Cass. civ., Sez. Unite, Ordinanza, 18/08/2025, n. 23474

Usi civici – Commissario regionale per la liquidazione – controversie – atti amministrativi – illegittimità – competenza - disapplicazione

Il Commissario regionale per la liquidazione degli usi civici, nell'ambito delle controversie devolute alla sua cognizione, dispone dei poteri necessari per disapplicare gli atti amministrativi illegittimi, ai sensi dell'art. 4 della legge 20 marzo 1865, n. 2248, all. E, al fine di ripristinare la destinazione ad uso civico dei terreni.

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