REA
RIVISTA DI ECONOMIA AGRARIA

crea
Consiglio per la ricerca in agricoltura e l'analisi dell'economia agraria

sidea

ITALIAN REVIEW OF AGRICULTURAL ECONOMICS

SECTORAL AND GEOGRAPHICAL DISPARITIES IN RURAL AREAS: EXPLORING DIFFERENCES AND POLICY OUTCOMES

FIRENZE UNIVERSITY PRESS

Vol. 80 | n. 3 | 2025

Italian Review of Agricultural Economics

Vol. 80, n. 3 – 2025

Firenze University Press

Italian Review of Agricultural Economics
https://www.fupress.com/rea
ISSN 0035-6190 (print) | ISSN 2281-1559 (online)

OPEN ACCESS

Published by Firenze University Press

Firenze University Press
Università degli Studi di Firenze
via Cittadella, 7, 50144 Firenze, Italy
www.fupress.com

REA | ITALIAN REVIEW OF AGRICULTURAL ECONOMICS

Firenze University Press
www.fupress.com/rea

OPEN ACCESS

Citation: Mantino, F. (2025). Bridging the gap between agricultural economics research and institutions: essays in memory of Gerardo Delfino. *Italian Review of Agricultural Economics* 80(3): 3-5. DOI: 10.36253/rea-16901

Received: November 26, 2025

Revised: November 26, 2025

Accepted: December 19, 2025

Data Availability Statement: Data will be made available by the corresponding author upon request.

Competing Interests: The Author(s) declare(s) no conflict of interest.

ORCID
FM: 0000-0001-5338-4333

Editorial

Bridging the gap between agricultural economics research and institutions: Essays in memory of Gerardo Delfino

Francesco Mantino

CREA – Research Centre for Agricultural Policies and Bioeconomy, Italy
E-mail: francesco.mantino@crea.gov.it; francomantino5@gmail.com

Studies on the territorial diversity of agriculture and rural areas have long been a core activity of the National Institute of Agricultural Economics (INEA), established in 1928. Until the early 1980s, INEA primarily focused on managing the Farm Accountancy Data Network (FADN) and publishing the annual report on Italian agriculture, *Annuario dell'Agricoltura Italiana*. After a period of crisis caused by budget constraints during the 1970s, it was only in the second half of the 1980s that INEA embarked on a new path, initiating research programmes that substantially diversified its scientific output.

Alongside this transformation, INEA invested in human capital – recruiting a new generation of agricultural economists, rural sociologists, and agronomists, motivated by the ambition to develop the autonomous capacity to design and interpret the evolving needs of the farming sector. Gerardo Delfino is at the heart of this evolution. From the very beginning, his vision and intellectual curiosity inspired this transformation. As a senior researcher and later Managing Director at INEA, Gerardo was not only a distinguished scholar but also a catalyst for institutional change. His intellectual curiosity and wide-ranging interests defy easy categorisation, making it impossible to confine his contribution to a single theme within agricultural economics. This forward-looking process continued over the following decades, culminating in the transformation of INEA into today's Council for Agricultural Research and Analysis of Agricultural Economics (CREA). This special issue is dedicated to honouring Gerado Delfino's legacy of ideas, passion, and unwavering commitment that has shaped INEA and continues to resonate within the scientific community today.

One of the defining threads running through Delfino's work was his commitment to policy design grounded in evidence. He understood that sound decisions require solid foundations, and this conviction was reflected in his meticulous attention to data collection on the agricultural sector – most notably through the FADN system. Under his contribution, this tool was steadily refined, enabling a deeper understanding of the Common Agricultural Policy (CAP) and related measures and ensuring their impact could be monitored across all regions.

Delfino was a tireless advocate for dialogue – an ongoing conversation between scientific research and the institutions shaping agricultural policy. He encouraged us, as researchers, to reach beyond the confines of academia, to engage with decision-makers, to understand the evolving needs of the sector, and to offer meaningful support through capacity-building. His vision of stakeholder engagement was broad and inclusive: not limited to public authorities, but extending to environmental organisations, producer groups, parks and protected areas, and non-governmental organisations (NGOs).

Equally remarkable was his sensitivity to the challenges facing Mediterranean rural areas, particularly those most vulnerable to relentless depopulation and demographic decline. He promoted studies on the role of extension services – a cornerstone of INEA's programmes – emphasising the training and professional development of agricultural advisors, who serve as vital bridges between innovation and practice.

The articles included in this special issue address some of the most recurrent themes in Delfino's work as a research manager. The overarching focus of these articles is on sectoral and geographical disparities in rural areas and the role of European Union (EU) policies in addressing these challenges. While sharing this common concern, the contributions differ in their approaches to representing these disparities and in the types of policies they examine.

E. Erjavec, I. Rac, and D. Bertolozzi-Caredio examine the recent CAP reform introducing the CAP Strategic Plans (CSPs). Their analysis reveals that many CSPs resemble a collection of interventions with limited overall coherence. This study underscores persistent gaps in integrating scientific evidence, developing methodologies, fostering interdisciplinarity, and improving communication between researchers and policymakers. Extending this approach to other policies – such as the Cohesion Policy – in the post-2027 reform appears highly challenging unless lessons from the current experience are effectively addressed.

F. Mantino, G. De Fano, and G. Asaro examine factors limiting the participation of declining territories in EU-funded programmes (European Regional Development Fund [ERDF], European Social Fund [ESF], and European Agricultural Fund for Rural Development [EAFRD]). Their analysis shows that demographic characteristics and administrative efficiency are decisive in explaining disparities in fund absorption. The impact of these funds on reducing territorial gaps varies: positive for rural development policies, moderate for the regional fund, and highly controversial for the social fund. The Lisbon Treaty (Art. 174) broadens territorial cohesion to include rural areas and territories with permanent natural or demographic disadvantages – such as sparsely populated regions, islands, cross-border areas, and mountains. The findings indicate that ERDF and EAFRD significantly support access to essential services and digital infrastructure. However, the study highlights a critical challenge: the limited and underexplored complementarity among Funds across rural areas, which calls for improved policy design.

Continuing the analysis of how policies have addressed territorial disparities, M.R. Pupo D'Andrea, F. Carillo, A. Scardera, and R. Henke show that, despite the redistributive efforts embedded in the CAP – particularly through the internal convergence mechanism – the income gap between the North and South Italian macroregions has persisted and, in some cases, even widened. Farm-level data confirm that the CAP has not succeeded in reducing these territorial disparities, despite South Italy receiving relatively more support than North Italy in 2014 and especially in 2022. The authors conclude that this evidence does not call for additional financial support but rather for structural changes to close the gap in a permanent, more efficient way. From a policy design perspective, addressing geographical agricultural income disparities requires building synergies with other funds operating at the same territorial level.

Among these complementary instruments, a strong role should be assigned to policies that strengthen the Agricultural Knowledge and Innovation System (AKIS), which has evolved significantly within the CAP over the last two decades. F. Giarè and A. Vagnozzi analyse the evolution and implementation of AKIS policies in addressing agricultural needs, with a focus on the Mezzogiorno. These policies have shifted from the traditional advisory and training tools of the 1990s to a holistic approach promoting networks, interactivity, co-innovation, and the adaptation of research to local contexts. Adoption, however, has been uneven and financially limited: AKIS resources represent less than 2.7% of regional allocations (1.5% in the Mezzogiorno), reflecting disparities in organisational models, institutional capacity for innovation, and the role of public and private service providers.

A. Cavallo, L. Mastronardi, G. Cannata, and L. Romagnoli investigate territorial disparities in environmental and socio-economic conditions, focusing on the fragility of mountain areas – defined as a multidimensional construct linked to exposure to hazards and the capacity to respond and recover. Their model confirms the interdependence between environmental and socio-economic fragilities, consistent with the literature. The results highlight marked heterogeneity across Italian mountain ecosystems: in many north-eastern municipalities, demographic vitality and favourable environmental conditions create virtuous circles that sustain rural vibrancy. Conversely, in the central Apennines, demographic decline persists despite good environmental conditions, while in southern mountains, demographic and environmental weaknesses increasingly reinforce each other, forming a vicious circle.

The papers included in this special issue offer valuable insights for the forthcoming reform of EU policies for the 2028-2034 programming period. The proposals presented by the European Commission in July 2025 regarding the Multiannual Financial Framework (MFF) for 2028-2034 and the associated restructuring of the EU policy architecture can be interpreted in light of the research findings discussed herein. Readers will find relevant elements for reflection in the contributions' conclusions and policy implications, both in the domain of the European Cohesion Policy and the two pillars of the CAP.

The first three papers highlight key challenges that may arise from this new institutional governance framework, particularly the risk that the agricultural sector could experience reduced bargaining power within national contexts. This concern underscores the importance of ensuring that sectoral priorities are not overshadowed in the pursuit of greater integration and simplification.

Bridging scientific research with policy reform and implementation has always been a demanding challenge for those committed to applied research. It requires time, a long-term vision, multidisciplinary approaches, relational skills, and a constant effort to maintain dialogue with institutions. These elements are essential for refining our understanding of problems and opportunities, identifying the positions and bargaining power of different stakeholders, and assessing the feasibility of policy proposals.

There are no training programmes, university courses, or master's degrees that can fully impart these qualities; only concrete field experience can do so. During the years of Delfino's leadership and coordination, INEA was an extraordinary school for many of us. We all owe him that invaluable lesson – both policy-oriented and profoundly human. This heritage enabled our research centre, over time, to become a recognised reference point for national and regional institutions responsible for agricultural and rural policy. Delfino's vision and dedication have been instrumental in building a stronger scientific community and in forging a culture of dialogue and trust between research and policy. This culture continues to inspire us today.

REA | ITALIAN REVIEW OF AGRICULTURAL ECONOMICS

Firenze University Press
www.fupress.com/rea

Research article

Common Agricultural Policy Strategic Plans: Smokescreens or instruments for evidence-based policymaking?

Emil Erjavec[1,*], Ilona Rac[1], Daniele Bertolozzi-Caredio[2]

[1] *Biotechnical Faculty, University of Ljubljana, Slovenia*
[2] *European Commission, Joint Research Centre (JRC), Seville, Spain*
*Corresponding author. E-mail: emil.erjavec@bf.uni-lj.si

Citation: Erjavec, E., Rac, I., & Bertolozzi-Caredio, D. (2025). Common Agricultural Policy Strategic Plans: Smokescreens or instruments for evidence-based policymaking? *Italian Review of Agricultural Economics* 80(3): 7-21. DOI: 10.36253/rea-16856

Received: November 7, 2025

Revised: December 9, 2025

Accepted: December 19, 2025

Data Availability Statement: Data will be made available by the corresponding author upon request.

Competing Interests: The Author(s) declare(s) no conflict of interest.

Guest Editor: Francesco Mantino

ORCID
EE: 0000-0002-4577-0178
IR: 0000-0003-4344-267X
DBC: 0000-0002-3709-7358

Abstract. Alongside the devolution of decision-making powers to Member States, the latest reform of the Common Agricultural Policy (CAP) introduced CAP Strategic Plans to enhance the design and implementation of increasingly complex policy objectives and to reinforce the use of evidence-based policymaking (EBPM). This paper is based on desk research, combining a comparative review of European Union (EU) regulations and programming documents, and insights from the Tools4CAP project, which conducted interviews, surveys, and focus groups across Member States. The gaps in strategic planning are evident in the weak logical connection between individual phases of CSP preparation and the weak evidence-based justification of decisions regarding the selection and design of interventions. Quantitative tools and scientific evidence were underutilised, while political-economy constraints and path dependency dominated decision-making. As a result, CAP Strategic Plans were often developed through a series of disconnected tasks, producing documents with loosely linked sections lacking overall coherence. The upcoming integration of CAP planning into broader National and Regional Partnership Plans may simplify procedures but risks weakening EBPM principles. Systematic integration of science into planning, methodology development, interdisciplinarity, and better communication between researchers and decision-makers are needed to realise the ideal concept of EBPM. Institutional capacities for the use of evidence need to be strengthened, mandatory impact assessments and open data platforms introduced, and dialogue between science and policy enhanced. The limitations include reliance on secondary data and qualitative insights rather than detailed empirical evaluation across all Member States.

Keywords: common agricultural policy, strategic planning, policy cycle, science-policy dialogue, Multiannual Financial Framework.
JEL codes: Q1, Q18, P00.

HIGHLIGHTS

- CAP Strategic Plans for 2023-2027 deviate significantly from EBPM principles, with weak intervention logic, limited use of quantitative tools, and strong path dependency. Most Member States favoured procedural compliance over systematic use of evidence.

- The post-2027 proposal simplifies planning but removes some EBPM elements such as SWOT analysis, potentially undermining strategic depth.
- Strengthening institutional capacity, integrating research systematically, and promoting science-policy dialogue are essential to improve CAP planning; peer learning and targeted impact assessments could bridge current gaps.

1. INTRODUCTION

Since 1992, reforms of the Common Agricultural Policy (CAP) have gradually introduced strategic planning into the way the needs, objectives, and interventions are defined. This began in the 1990s with the introduction of programmes for rural development policy, the CAP's second pillar (Dwyer *et al.*, 2007), and intensified through successive reforms that progressively strengthened the intervention logic, performance orientation, and multiannual programming. The process culminated in the 2021 reform (Munch *et al.*, 2023), which for the first time made strategic planning mandatory for both pillars of the CAP through the requirement to develop CAP Strategic Plans (CSPs). With the introduction of CSPs for the 2023-2027 period, the European Union (EU) has attempted to strengthen the evidence-based approach, to adapt it more closely to national characteristics and needs, and to improve the management of this public policy (De Castro *et al.*, 2020; Erjavec, Rac, 2023). These ambitions are grounded in a shift towards results-based and performance-oriented policy design, drawing on the logic of results-based management (RBM) (Mayne, 2007) while aspiring to meet the principles of evidence-based policymaking (EBPM).

Regulation (EU) 2021/2115 defines the procedure for preparing CSPs. Each Member State (MS) develops its own intervention strategy based on (i) Strengths, Weaknesses, Opportunities, and Threats (SWOT) analysis and needs assessment; (ii) targets and milestones for common result indicators; (iii) the selection and design of interventions with clear links to specific objectives; and (iv) the allocation and justification of financial resources. The plans include various interventions selected from a menu of predefined types also specified in Regulation (EU) 2021/2115 (Folkeson *et al.*, 2023). The so-called "New delivery model" of the policy is intended to be performance-based, fundamentally based on a common monitoring and evaluation framework, and supported by annual performance review and multi-year evaluation cycles consistent with the principles of RBM (Mayne, 2007).

The CSPs were developed through a comprehensive and structured dialogue with national (or even regional) stakeholders (Cagliero *et al.*, 2022), with the European Commission playing a central role by issuing recommendations, reviewing intervention logic, and ultimately approving each plan. *Ex ante* evaluators were also required to assess needs assessments, prioritisation processes, data adequacy, intervention logic, and indicator setting. The European Commission synthesised its findings in recommendations published in late 2020, stressing the contribution of CSPs towards reaching Green Deal targets by setting explicit national targets, drafting effective plans by ensuring transparency and complementarity with other policies, and strengthening participation of stakeholders and civil society in both design and implementation (European Commission, 2020). According to an analysis of all draft plans (EU CAP Network, 2023), the CSPs were generally grounded in comprehensive data analysis, demonstrated relatively logical needs prioritisation, aligned interventions with identified challenges, and showed enhanced environmental ambition. However, it also revealed recurring weaknesses, including unclear needs formulations, variable coherence (internal and external), inconsistent consideration of lessons learned and Green Deal targets, gaps in intervention logic, insufficient attention to gender, data limitations, and uncertainties about simplification and the potential effectiveness of interventions.

A major issue that has arisen relates to the quality of CAP strategic planning and how it can be improved. In this context, we understand the notion of "quality" of strategic planning in public policy in accordance with EBPM. This multidimensional concept includes effectiveness, coherence, evidence-based design, stakeholder involvement, and adaptability (Cairney, Oliver, 2017; Dicks *et al.*, 2014; Sanderson, 2002; Strydom *et al.*, 2010). Research on strategic planning further emphasises the importance of robust need assessments, transparent prioritisation, and clear intervention logic (or logic model) as core determinants of planning quality (e.g., Bryson, 2018; Bryson *et al.*, 2018; Howlett, Mukherjee, 2018; Mayne, 2007).

The CAP undergoes substantial revisions every seven years, typically aligned with updates to the Multiannual Financial Framework (MFF), which serves as the EU's overarching budgetary planning instrument. The European Commission's proposal on the MFF for the period after 2027 (European Commission, 2025a, 2025b, 2025c) also includes a significant change for the CAP. According to the proposal, strategic national planning of certain EU policies (Cohesion, Agriculture and Rural, Fisheries and Maritime, Prosperity and Security) will be combined in a single National and Regional Partnership Plan (NRPP) specific to each MS. The proposed Regulation (COM (2025) 545) would replace the existing CSP Regulation (EU 2021/2115) and integrate the CAP into the broader horizontal framework for EU budget management. The aim is to harmonise the rules for performance monitoring, the use of indicators, data reporting, policy coherence, and transparency of spending across all EU policies. This represents a major shift in CAP planning architecture, raising questions about whether integration will enhance or weaken the quality of agricultural policy planning as defined above.

Strategic planning can improve the performance of public policies by introducing structured, evidence-based, and goal-oriented approaches to policy design, implementation, and evaluation (Bryson, 2018). This is especially true for agricultural policy, which involves complex and multidisciplinary issues (El Benni *et al.*, 2023). Yet, unlike stakeholder consultation, the inclusion of scientific research communities is not formally required in the CSP Regulation, despite the shortcomings in needs formulation, prioritisation, and intervention logic (EU CAP Network, 2023). This prompts the question: would more systematic and mandatory integration of scientific evidence improve the quality of CAP strategic planning?

This article is grounded in EBPM, a term often used in political discourse and scientific practice (Cairney, Oliver, 2017; Sanderson, 2002; Styrdom *et al.*, 2010). Cairney (2016) argues that EBPM is better understood as an aspiration rather than a description of real-world decision-making. He highlights the intricate dynamics between science and politics and critiques the simplistic belief that scientific evidence should automatically dictate policy decisions. Politicians operate in complex environments where evidence is often not the only (or main) factor. Their decision-making is characterised by bounded rationality (Cairney, 2016). This means that they cannot process all the information available; instead, they often rely on simplifications, taking irrational shortcuts in decision-making based on emotions, ideology, and habits (cf. Howlett, Mukherjee, 2018). These well-known (e.g., Rondinelli, 1976) dynamics of public decision-making help explain where CSP preparation diverges from the rational EBPM ideal and how much improvement is realistically feasible under existing institutional and political constraints.

The aim of this paper is to evaluate the quality of CAP strategic planning, to assess how it can be improved, and to analyse the implications of the proposed post-2027 reform. We answer the following research questions:

1. How can CSPs be assessed from the perspective of EBPM, thereby contributing to a more theoretically grounded understanding of the quality of strategic planning (CSPs and EBPM)?
2. Could the institutional changes to CAP programming after 2027 proposed by the European Commission, with the CAP being placed in a common strategic and programmatic framework with other traditional policies, also mean a potential change in the quality of strategic planning and, consequently, of the CAP (the CAP and NRPP)?

2. METHODOLOGY

2.1. Theoretical framework

We frame our methodology around the literature on EBPM, which we understand as a set of principles and practices intended to improve the quality of policy design, implementation, and evaluation. EBPM provides a useful analytical lens for assessing strategic planning because it emphasises robust problem analysis, the systematic use of evidence, and the evaluability of intervention logic. In addition, we draw on theoretical frameworks from public policy (Cairney, 2016; Cairney, Oliver, 2017), policy design (Howlett, Mukherjee, 2018), evaluation studies (Mayne, 2007; Sanderson, 2002; Weiss, 1998), and strategic management (Bryson, 2018; Johnsen, 2015) that examine how research, expertise, and analytical tools inform and shape policy decisions.

Theories of strategic planning and EBPM

The theoretical background of the practice of public-sector strategic planning encompasses a range of conceptual frameworks that explain how public institutions formulate (design), implement, and evaluate strategies to achieve policy goals (Bryson, George, 2024). Rather than a single overarching theory of strategic planning, the literature comprises several disciplinary traditions that together inform how strategic planning is understood in public governance (Howlett, Mukherjee, 2018; Johnsen, 2015). We do not presume to be exhaustive in our review.

The basic conceptual vehicle for this paper, as well as CSPs, is the basic rational-procedural planning model (Bryson, Edwards, 2017; Sanderson, 2002), which assumes that strategic planning is a linear, logical, evidence-based process of goal setting, analysis, strategy formulation, implementation, and evaluation. Bryson (2018) defines strategic planning as deliberative and disciplined. This procedural logic is also reflected in the formal regulatory requirements for CSPs (Regulation (EU) 2021/2115), which prescribe a mostly linear sequence of needs assessment, prioritisation, intervention design, and performance monitoring.

The theory of strategic management helps contextualise this process. It emphasises deliberation, stakeholder engagement, organisational effectiveness, legitimacy, and public value (Bryson, 2018). From this viewpoint, the quality of strategic planning depends not only on procedural rationality but also on the (deliberative) alignment of goals, evidence, administrative capacities, and stakeholder expectations, resulting in enhanced effectiveness of societal systems. The quality of strategic planning is important because it increases the effectiveness and efficiency of policy, reduces administrative burdens, enables better management of public funds, and strengthens trust in institutions (Poister, Streib, 1999). Strategic planning does not ensure good results (Bryson, 2018).

Evaluation studies and evidence-use scholarship clarify the role of research and analytical reasoning in strategic planning. Evaluation theorists such as Sanderson (2002) and Weiss (1998) emphasise that evidence is essential for understanding policy problems and assessing alternatives, as well as highlight the importance of articulating plausible theories of change or logic models. RBM frameworks stress the importance of linking expected outcomes to activities through result chains, reflecting an intervention's underlying intervention logic (Mayne, 2007). These contributions reinforce the expectation that high-quality planning should rest on robust needs assessments, justified prioritisation, and explicit causal reasoning. This expectation is captured in the normative concept of EBPM, which means designing public policies based on the best available scientific evidence (Cairney, 2016).

However, EBPM is difficult to implement in the real world, and its rationalist basis has often been criticised (Cairney, 2019; Sanderson, 2002). We follow Cairney's (2016) argument that the required type of rationality is limited in the real political-economic context. Policymakers operate under bounded rationality, political incentives, and institutional constraints, all of which limit the extent to which evidence can directly shape decisions. Political dynamics often outweigh scientific arguments, evidence is interpreted differently by different actors, and decision-makers frequently rely on heuristics due to time and capacity constraints. Therefore, the incorporation of evidence into policy requires active engagement through coalition-building and collaboration with decision-makers on the part of scientists, including translation and embedding of evidence in the political context, rather than assuming that evidence will automatically guide decisions (Sanderson, 2002).

There is no uniform definition of the quality of strategic planning in the literature. Based on the combined insights of strategic management, policy design, and evaluation scholarship, we conceptualise quality in strategic planning as the degree to which planning processes are analytically grounded (robust needs assessment), deliberatively justified (transparent prioritisation), and causally coherent (clear intervention logic). We aim to define the quality of strategic planning in alignment with the EBPM ideal, in a way that helps answer the questions posed in this article, while acknowledging the concept's practical limitations.

Table 1 summarises the key characteristics of EBPM in agricultural policy. Each criterion is grounded in theoretical traditions and reflected in the regulatory requirements of Regulation (EU) 2021/2115. We investigate how these principles are implemented in the regulatory and implementation framework of the CSP for the 2023-2027 period.

2.2. Methods of analysis

The analysis is based on desk research, combining comparative analysis of legal and programming documents, interviews and online surveys with the persons involved in CSP formulation, focus groups, and the inclusion of the authors' experience and expertise in research support for the planning of the CSP (Slovenia) for the current period (2023-2027) and the post-2027 period.

A significant portion of this information and expertise stems from the work conducted within the Tools4CAP project (Tools4CAP Consortium, 2023a, 2023b, 2024a, 2024b, 2024c). Specifically, 121 interviews across 25 MSs[1] were undertaken in 2023 with stakeholders from ministries, governmental bodies, paying agencies, regional and local authorities, scientific and research institutes, consulting firms, farmer and agricultural organisations, and environmental and consumer organisations (Tools4CAP Consortium, 2023a, 2023b). The interviewees were identified through selective sampling, as the main goal was to involve knowledgeable actors who had a role in the CSP process. The main objective of these interviews was to map all the steps of the CSP design process, and the methodological tools used across the steps.

In the same year, 77 online surveys were collected in 16 MSs, involving stakeholders from scientific and research institutes, ministries, and consulting firms (Tools4CAP Consortium, 2024a). The main objective of the survey was to evaluate the methodological tools employed along the CSP design process. The partici-

[1] All MSs except Denmark and Estonia.

Table 1. Evidence-based policy making model for agricultural policy.

Principle	Description	Sources	Regulation (EU) 2021/2115 articles
Precise definition of needs and clear long-term goals	Specific needs for public intervention are clearly defined and, where possible, quantified; priorities and objectives derive directly from these needs and specify what the policy aims to achieve.	Bryson, 2018; Howlett, Mukherjee, 2018; Johnsen, 2015; Sanderson, 2002; Weiss, 1998	104, 108, 109
Balanced consideration of various elements of sustainability	A diverse and balanced consideration of economic, environmental, and social aspects relevant to agricultural sustainability and the broader food system.	Howlett, 2018; Sanderson, 2002	6, 109
Targeted and measurable optimal measures	A clear and evidence-based intervention logic links measures to objectives; selected measures are appropriate for achieving the objectives, and their expected results and effects are measurable.	Howlett, Mukherjee, 2018; Johnson, 2015; Mayne, 2007; Weiss, 1998	109, 111, 112
Transparent allocation of budgetary resources for individual interventions	Financial resources are allocated transparently and in line with priorities and the long-term strategic vision, with clear justification for allocations to specific measures and objectives.	Mayne, 2007; Poister, 2010; Weiss, 1998	109, 112
Comprehensive performance measurement and evaluation	Specific indicators enable systematic monitoring of implementation, and continuous tracking supports timely policy adjustment in line with progress toward objectives.	Mayne, 2007; Sanderson, 2002; Weiss, 1998	128, 129, 134, Annex I
Wide use of empirical evidence and tools	Decisions are informed by data, research, evaluations, and analytical tools that support effect assessment and the formulation of new or improved measures.	Cairney, 2016; Cairney, Oliver, 2017; Howlett, 2018; Weiss, 1998	104-106, 108, 109, 128-132
Broad participatory approach to strategic planning	An inclusive participatory process engages stakeholders representing diverse sustainability interests, including interest groups, experts, and public authorities, throughout all stages of agricultural policy planning.	Bryson, 2018; Howlett, Mukherjee, 2018	123-126
Implementation of policy cycle principles: adaptability and learning culture	Cyclical strategic planning promotes iterative learning and adaptation across all phases of the policy cycle.	Bryson, 2018; Cairney, 2016; Johnsen, 2015; Sanderson, 2002	132-135

Source: authors' elaboration.

pants were self-selected, as the survey was open in all MSs (translated in all EU languages) and to any type of stakeholders that were involved in the CSP process (e.g. policymakers, researchers, consultants, etc.).

Lastly, 14 national focus groups were held in 2023 in 14 MSs[2], bringing together policymakers, non-governmental organisations (NGOs), agricultural representatives, environmental advocates, agricultural experts, and rural stakeholders (for the methodological details, see Tools4CAP consortium, 2024b). The focus groups were used to identify the main challenges faced during the preparation of the CSPs and ways to improve the process.

Based on this information, the Tools4CAP project produced (i) an inventory of methods and tools used during the CSP design process across MSs; (ii) a mapping of the actual CSP design process and tasks conducted by MSs, as well as main differences and commonalities among MSs; (iii) an evaluation of the employed tools in the CSP design process; and (iv) the identification of main challenges and needs to improve the CSP design process. The paper largely relies on the analysis of these outputs.

We addressed our first research question as follows:

i. desk research, specifically the results of the Tools4CAP project to date;
ii. preparation of a theoretical framework with principles and elements of assessment (Table 1);
iii. an assessment and recording of theses;
iv. verification of these theses through individual interviews and public presentations (performed twice).

Moreover, we addressed our second research question as follows:

i. analysis of MFF proposals related to CAP strategic planning (desk research, participation in public presentations, and discussions with government officials) and formulation of hypotheses;

[2] Specifically, Spain, France, Italy, Germany, the Netherlands, Poland, Czechia, Romania, Bulgaria, Hungary, Slovenia, Lithuania, Latvia, and Ireland. These countries were selected according to the coverage of the consortium's partners.

ii. verification of theses in a round of discussions with CAP experts and state officials).

3. RESULTS

3.1. Evaluation of CSPs from the perspective of EBPM

In accordance with Regulation (EU) 2021/2115, MSs must develop CSPs that cover their national territory; ensure consistency with regional circumstances (Cagliero *et al.*, 2022); and establish a monitoring, reporting, and evaluation system. Thus, the process of CAP strategic planning begins with programming and continues through implementation. It encompasses all activities carried out by MSs, including preparatory work, which is developing the "sound intervention logic" of the CSP (referred to in Article 109(1)(b)) and the intervention strategy (in Article 107(1)(b)) for each specific objective.

As per Regulation (EU) 2021/2115, the development of the CSP involves specific tasks, including socio-economic and context analysis, SWOT analysis, needs assessment, identification of measures, setting of targets, allocation of financial resources, ex-ante analysis and strategic environmental assessment (SEA), and stakeholder consultations (Figure 1).

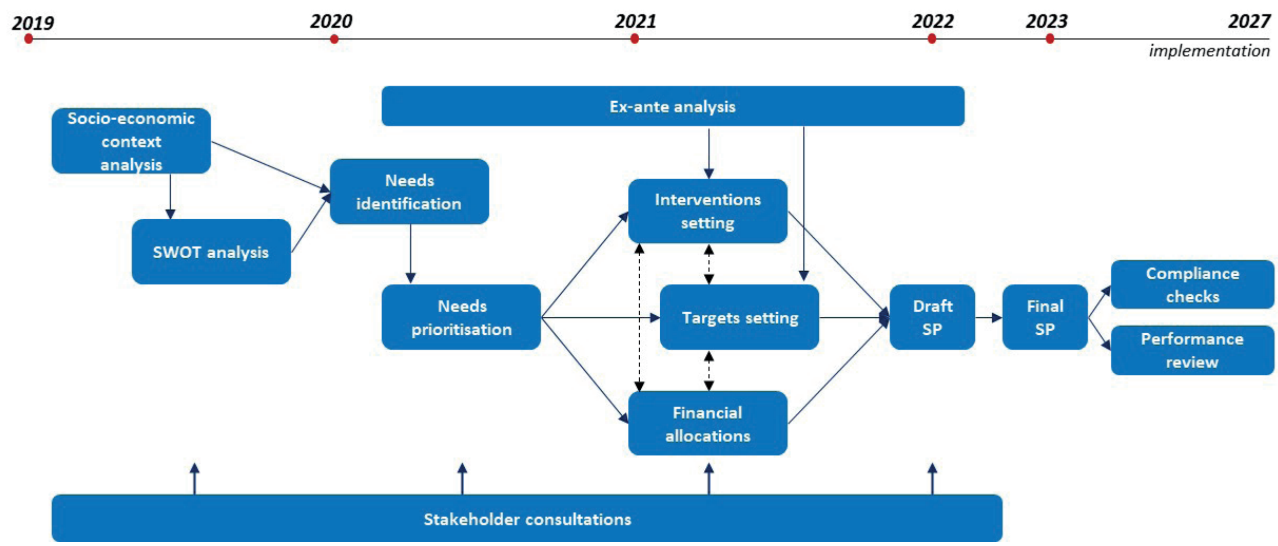
The preparation of CSPs for the current period (2023-2027) was formalised and conducted as an administrative procedure. MSs followed the procedures set out in the regulation and guidelines for individual elements (tasks or design steps) provided by the European Commission (Directorate-General for Agriculture and Rural Development [DG AGRI]). Naturally, MSs differed in organisational styles and the approaches used to complete these elements. Some sources presenting the CSP are already available (Cagliero *et al.*, 2023; European Commission, 2023a; European Court of Auditors, 2024; Folkeson *et al.*, 2024; Mezzacapo, 2024; Munch *et al.*, 2023; Runge *et al.*, 2022). With the help of process analysis and the inclusion of CSP support tools, which was carried out in the Tools4CAP project (Tools4CAP Consortium, 2023a), we can broadly outline the common characteristics of strategic planning that allow for the assessment of deviations from the EBPM ideal.

Needs assessment and priority setting

Socio-economic analyses were very broad in scope and attempted to highlight all elements of sustainability in relation to specific CAP objectives. They mainly summarised previous research and were based on available sources. The SWOT analyses derived from them were generally broad and attempted to highlight the key challenges facing agriculture and the corresponding needs of agricultural policy at the national level (EU CAP Network, 2023). In the next step of needs prioritisation, MSs mainly relied on the specific objectives that emerged from the CAP reform at the EU level.

The comparative analysis among MSs (Tools4CAP Consortium, 2023b) revealed relevant differences in the approaches to needs assessment and prioritisations.

Figure 1. Schematic example of the design steps for the Common Agricultural Policy (CAP) Strategic Plan.



Source: Tools4CAP Consortium (2023b).

While the interviewees considered the conducted exercise generally successful in all MSs, the identification, definition (i.e., level of detail), and method and scale of prioritisation were very different among MSs and, in certain cases, were strongly affected by arbitrary or subjective choices. The interviewees and surveyed stakeholders expressed the most concerns in relation to the representativeness of stakeholder selection, which can have huge impacts on the final outputs (Tools4CAP Consortium, 2024c).

Balanced consideration of sustainability

The balanced consideration of various elements of sustainability was implemented very differently among MSs. Most prioritised economic aspects (Munch *et al.*, 2023), while environmental ambition varied (Runge *et al.*, 2022). The European Commission has encouraged the strengthening of this part of the policy through alignment with the Green Deal, but without significant success (European Court of Auditors, 2024). The CSP analysis clearly revealed that the weakest link is social sustainability, which falls short, not only in the selection of interventions and the allocation of financial resources, but already at the level of conceptualising issues and needs (Organisation for Economic Co-operation and Development, 2024).

Intervention logic

As expected, the selection and definition of interventions were the focus of strategic planning. Ring-fencing and path dependency based on previous programming periods were very evident and led to similar policy choices (Cagliero *et al.*, 2023). Only a few countries made more radical changes to their set of measures compared with the CAP for the 2014-2022 period (see, for example, the comprehensive analyses provided in European Commission, 2023b).

The public discussion in the MSs on the CSP was thus primarily a discussion on measures (and later about the allocation of funds). The link between interventions and needs and priorities was often weak. Overarchingly, the selected interventions were linked with the objectives they were meant to pursue, but without detailed analysis on the anticipated strength of the impact, a description of the mechanisms contributing to the objectives, a discussion of possible negative or unanticipated impacts, or coherence between the interventions.

Analysis of the CSPs revealed several inconsistencies between needs prioritisation and intervention- or target-setting, or at least the logical link between the prioritised needs and chosen intervention was not made explicit (European Commission, 2023b). With rare exceptions (e.g. the Netherlands and Germany), tools such as the Intervention-Objective-Impact (IOI) matrix or Eco-Scheme modelling tools were not used to assess the potential contribution of interventions to objectives. Thus, the formulation and application of sound intervention logic, as stipulated by the Regulation (EU) 2021/2115 (Article 109(1)(b)), is certainly a weak link in ensuring coherence and effectiveness in CAP implementation.

Budget allocation

In the preparation of strategic plans, the biggest black box is the allocation of financial resources for individual interventions. In fact, when analysing the use of scientific or other methodological tools across the different tasks by MSs (Tools4CAP Consortium, 2023b), we found that almost no MS made use of any tool (including stakeholder engagement tools) between intervention-setting and financial allocation. According to the surveyed stakeholders and focus groups participants, this could be identified as the main site of backroom politics. Proposals were mainly developed in decision-making circles and then negotiated with interest groups, other ministries, and the European Commission. Here, the level of EBPM and participation was probably at its lowest. This is the reality of the political process, which, according to Cairney (2016), cannot be avoided.

While the CSP approach makes it possible to include a *precise definition of needs,* the exact extent to which individual MSs succeeded in this would require further study. However, to maximise absorption of EU funds, there is a strong incentive for MSs to adapt nationally defined needs to the given “eligible” needs and specific objectives of the EU funding framework (cf. Organisation for Economic Co-ordination and Development [OECD], 2020). This kind of conversion significantly weakens the potential for constructing appropriate intervention logic, making it difficult to fulfil the requirement for “targeted and measurable optimal measures”. Thus, interventions were already largely predefined through regulation and policy lock-in (cf. Popp *et al.*, 2021), related to the path dependency mentality of decision-makers. We can conclude that the deviation from the EBPM is most striking in the criterion “transparent allocation of budgetary resources for individual interventions”. Here, political-economic realities prevailed.

Performance review and empirical evidence

Performance planning, required as part of CAP planning for the first time, remained limited to result and output indicators. Impact indicators will only be assessed after the end of the financial period. "Comprehensive performance measurement and evaluation" were often highlighted during negotiations before the legislation was adopted as something that would jeopardise the implementation of the CAP. However, at least until 2025, it has not gone beyond being necessary solely to comply with the regulation. For example, according to the conducted interviews (Tools4CAP Consortium, 2024c), only a few MSs planned to develop improved monitoring systems.

Apart from a few MSs, consistent "use of empirical evidence and tools" in all phases of planning was not particularly prevalent (Tools4CAP Consortium, 2023a), indicating weak exploitation of the potential of research to support quality strategic planning. The results showed a wide use of various tools but very little direct use of comprehensive EBPM approaches as shown in the proposed theoretical framework. At the time of preparation, based on this analysis, only a few countries (the Netherlands, Slovenia, Ireland, Belgium – Wallonia, and Germany) used quantitative models directly in the preparation of the CSP. In addition, the use of these tools was found to be limited to a few tasks, particularly intervention setting and *ex ante* analysis. We also found that these quantitative models were not used to comprehensively or jointly address multiple interlinked tasks (e.g. needs prioritisation, intervention setting, and target setting), even though this approach would have ensured more consistency and a stronger intervention logic (Tools4CAP Consortium, 2023b). Thus, the evaluation of applied tools (Tools4CAP Consortium, 2024c) revealed a significant gap between the amount of available quantitative tools (i.e., already applied in science or other policies) and the level of actual implementation for the design of CSPs. This was also widely reported by focus group participants across all MSs (Tools4CAP Consortium, 2024b). Consequently, we found both a need from policymakers and an unexploited potential.

None of the responsible ministries followed the example of the European Commission in conducting a broader impact assessment, commissioning additional quantitative or qualitative studies, let alone more modern approaches to designing measures using experimental economics. However, as noted by some of the interviewed stakeholders, many of the available quantitative models for policy support require a long time for set-up, while the policymaking process usually takes much less time. This fact might signal a need to better adjust the existing models to the needs of the policymaking process and to strengthen capacity to anticipate policy needs at the MS level.

Stakeholder involvement and policy learning

The demand for applying a participatory model was transferred from rural development, where it had already been applied during previous programming periods. MSs reported a relatively high level of stakeholder inclusion during the planning process. Considering that much of the planning occurred during the coronavirus disease 2019 (COVID-19) pandemic and under its associated restrictions, it is likely that participation would have been even higher under normal circumstances. However, the specific level of engagement also depended on the local culture of dialogue between government representatives, interest groups, and industry representatives, and the complement of consulted stakeholders often consisted of the "usual" narrow group of agricultural stakeholders, reflecting a persistent EU-wide need to broaden the policy arena in this sector (cf. de la Rosa, 2010; Hepping *et al*., 2025; Termeer, Werkman, 2011). Furthermore, many parts of the CSPs were created mainly via interactions between state officials and the European Commission in the form of a largely bureaucratic process.

An example given by the interviewees was the trade-off between open consultation involving civil society as a whole (which would dilute real sectoral needs and inflate very general issues that are not strictly agricultural), and sectoral consultation limited to farmers and a few other stakeholders (which would omit relevant issues related, for example, to environmental impacts, animal welfare, and climate change). According to the mapping and analysis of the strategic plans conducted by the European Commission (2023b), the prioritised needs were hardly comparable among the MSs and often very general or vague. In addition, the focus group participants often indicated a lack of supporting tools to properly analyse the information gathered from stakeholders (Tools4CAP Consortium, 2024b).

It will also be necessary to wait for an assessment of the extent to which the characteristics related to policy learning are actually implemented. Considering the limited quality of EBPM, those who argue that the policy cycle is difficult to implement in real-world settings (Hudson *et al*., 2019) may be proven correct.

Final assessment of strategic planning quality

To summarise, the CSP preparation included several quality control elements: a formal policy framework with ring-fencing of shares for certain measures, a formal environmental assessment, the involvement of stakeholders in public consultations, and, in particular, the recommendations of the European Commission. Nevertheless, the quality of the implementation of the intervention logic, the weak link between the SWOT analysis and the setting of priorities, and the path dependency logic of distribution of funds among individual measures reveal shortcomings in the quality of strategic planning for the 2023-2027 period. Unfortunately, there are no available evaluations of the final versions of the plans (EU CAP Network, 2023).

We can conclude that the prescribed procedures and a lack of quality control or quality standards for strategic planning (especially of the elaboration of the intervention logic, path dependency, weak incorporation of evidence, and poor impact assessments, if any) limited the quality of CAP strategic planning for the 2023-2027 period. This was conditioned by various political-economy constraints, ranging from the policy lock-in to interest-driven decision-making and the related ideational rigidity of the core policy community (cf. Hepping *et al.*, 2025), as well as all the constraints of the bureaucratic decision-making system. While this is not a surprise, these political-economy dynamics must be addressed if the quality of strategic planning is to be improved in line with EBPM in the future, if this is indeed in anyone's interest.

3.2. Future CAP strategic planning

The European Commission's proposal for the future CAP (2028-2034) within the MFF will also involve significant changes in the area of CAP strategic planning. The proposal merges CAP funding into a single National and Regional Partnership Plan (NRPP), which combines other traditional and large policies, such as regional, cohesion, and social policies, where MSs would independently plan measures in accordance with a common policy framework. The CAP would have its own chapter within a unified NRPP, prepared at the level of the entire government (not just agricultural ministries). This may have important implications for the need to provide a strong evidence base to substantiate agricultural policy spending, as well as from the perspective of a broader policymaking community.

The CAP strategic planning and implementation framework is defined by several new proposed regulations, notably proposed NRPF Regulation COM(2025) 565, the CAP Regulation, which determines the conditions for implementation of EU CAP support (COM(2025) 560), and the Performance Regulation, which covers budgetary expenditure tracking and performance (COM(2025) 545).

The key changes are mainly that CAP strategic planning is part of broader and comprehensive national planning and that CAP planning itself is moving towards simplification. A simple logic of strategic planning has been established, based on the setting of priorities, the selection of interventions, and results and output indicators.

Thus, the obligation to conduct a SWOT analysis – an important part of the current CSP that provides at least a minimum evidence base – has been omitted. It will be replaced by a European Commission steering mechanism, under which the European Commission will try to help define the need for intervention and maintain the common EU policy framework. The new proposal introduces a new set of objectives for the CAP, which are outlined less precisely than those in the existing CSP regulation (Regulation (EU) 2021/2115). Moreover, other elements that strengthen EBPM are not highlighted. The text of the proposals for new legislation does not include specification of SMART objectives, "ambitious targets", or intervention logic. The Performance Regulation is mostly about tracking and monitoring expenditure, but says nothing about how the NRPP (or the CAP subchapter) should be drawn up. The requirement for targets is shifted from result indicators to output indicators, which in turn are linked to intervention areas rather than measures. The evaluation system is changing: no *ex ante* evaluation is required, but the proposed Performance Regulation (COM(2025) 545) requires that MSs carry out an evaluation of the effects of the measures supported by quantitative tools during the programming period, where appropriate.

As with cohesion policy to date, strategic planning will focus on performance-based budgeting and budgeting for results. Spending must deliver the intended results, and the government must monitor how effectively the EU budget achieves its objectives. Indicators are linked to output and result indicators, but there is no explicit mention of impact or context indicators, which are in use in the current CSPs. Another key change is the governance of CAP strategic planning. The proposals strengthen the emphasis on partnership procedures and harmonise the application of horizontal principles across all funds.

New CAP strategic planning will certainly be simpler in terms of document preparation than under the current regulations. Priorities and interventions are highlighted, as well as their connection through the intervention logic. At the same time, result and output indicators are also key, as is already the case for cohesion policy.

Assessment of the new institutional arrangement from the perspective of EBPM

Can this new system eliminate some of the shortcomings regarding the requirements of EBPM, as presented above? This is certainly not the case from a systemic and regulatory point of view. Impacts must be quantified, but only in the mid-term review. The planning system highlights individual priorities and interventions, which can improve the intervention logic (i.e., a more precise definition of objectives and more result-oriented interventions). However, there will be no requirement to provide a comprehensive view of the CAP in terms of the required definition of long-term goals; *ex ante* impact assessment (which is also not the case now); a comprehensive system of indicators; or a comprehensive derivation of needs, priorities, and interventions. There is still no systematic requirement for the transparent allocation of funds across measures. It appears unlikely that the logic of the policy cycle will gain greater prominence, or that strategic planning will be characterised by broad and inclusive stakeholder participation.

The notion that MSs should identify reliable indicators is questionable, given that the European Commission has already pre-selected the output and result indicators that must be used. Thus, the new strategic planning system does not seem to bring about major improvements in terms of EBPM; on the contrary, it may lose the comprehensive view of the CAP, which was a requirement of the current regulation. The new regulation does not prescribe this for the time being, and it is possible that it will focus on individual planning priorities rather than on the CAP, undermining comprehensiveness. Similarly, the proposed ring-fencing of most funds for CAP interventions will likely push for partial rather than comprehensive approaches. This is not necessarily a negative development, as it could potentially mean greater achievement of individual societal objectives, at least in environmental and social sustainability, but the needs and interventions for food system and rural areas are so multifaceted and complex that such a simplified approach could reduce the effectiveness and efficiency of the policy.

A change in the governance of strategic planning will also contribute to a change in the overall view of the CAP. Agricultural ministries no longer have sole responsibility for coordinating CAP planning and implementation. Even greater coordination between ministries will be needed, with the ministry leading the preparation of the NRPP playing a key role. This approach has the potential to induce competition for funds at the national level, but it may also stimulate MSs to target their spending better and look for synergies or complementarities in an overall reduced budget. It is also interesting to note that the process for NRPP approval is changing, as the Council of the EU takes the final decision to approve the plans.

As indicated, however, the change in governance arrangements may also contribute indirectly to a greater implementation of evidence-based policymaking. The Ministry of Agriculture will compete with other ministries for funds that are not ring-fenced, which means that it will have to improve its justification for spending, especially in areas that require cross-sectoral cooperation, such as rural development, environmental spending, knowledge transfer, and the integration of agri-food chains. Thus, while the new EU public policy planning system at the MS level brings important procedural changes that do not necessarily strengthen EBPM in regulatory terms, MSs may choose to improve the definition of their needs and interventions. We can expect that the differences in administrative capacity and cross-sectoral cooperation will strongly affect the quality of strategic planning, potentially increasing differences between countries.

It should be noted that this assessment of the CAP strategic planning for the period after 2027 is based on the European Commission's initial proposals. Various modifications are possible during the negotiations on the future MFF. Changes may occur in terms of ring-fencing for the remaining interventions of the current CAP, such as general rural development measures, and the technical details of strategic planning and the competences of EU institutions regarding the CAP chapter in NRPP may also change.

4. DISCUSSION AND CONCLUSIONS

4.1. How can CAP strategic planning be improved?

Based on our analysis, the actual implementation and quality of CAP strategic planning deviates from the ideal case of EBPM we have defined. No phase of strategic planning is optimally designed in terms of usage of data; the intervention logic is relatively weak; and, above all, the choice of measures and resources for them is often determined based on previous entitlements (path dependency), ring-fencing instruments and funding, and short-sightedly, in pursuit of political interests. This does not mean that CAP planning lacks all strategic thinking, nor can it be denied that it is improving over time. It means that current CAP strategic planning for the 2023-2027 period has a few shortcomings that reduce the effectiveness and efficiency of this public policy.

The main factors contributing to the deviation from ideal CAP strategic planning are the political reality in which it is developed, the need for decision-makers to balance different interests, many of which are entrenched and directly involved in decision-making, and the presence of equally entrenched ideational frameworks. Consequently, evidence is not always at the forefront. As Cairney (2016) points out, policies are often shaped by emotions and stories, as they are created in complex decision-making processes involving many actors, with no guarantee that evidence will reach key decision-makers at the right time.

Decision-makers in institutions such as the EU and MSs can do a lot to improve EBPM. Cairney and Oliver (2017) suggest several concrete steps that institutions can take. It is important to strengthen institutional capacities for systematic collection, evaluation, and interpretation of evidence. It is also necessary to establish mechanisms for ongoing dialogue between researchers and decision-makers, through workshops and advisory committees where scientists, officials, and stakeholders can meet. It may even be possible to develop and use "knowledge brokers", who could serve as intermediaries between science and politics. It would also help to develop guidelines for the use of evidence in policymaking and to increase transparency by requiring the publication of evidence supporting legislative proposals. This also requires the promotion of open platforms where data are accessible to researchers and the public. Moreover, it is necessary to ensure civil servants have adequate knowledge and education so that they can understand the relevant statistics, methodologies, and research limitations, and critically assess evidence.

This endeavour mainly involves soft measures in terms of investing in science and maintaining a dialogue between scientists and decision-makers. However, it is also necessary to systematically support EBPM in EU and national regulations and implementation guidelines. The EU could prescribe impact assessments for setting priorities and selecting interventions. It could set a minimum level of data and records that a MS must include in the preparation of the CAP-related chapter (and other chapters, for that matter) of the NRPP.

At the MS level, training on strategic planning for civil servants and stakeholders should be developed and supported with public funds. As suggested by our interviewees, peer learning among MSs should also be supported through dedicated platforms, to promote the exchange and replication of best practices. MSs should also conduct or fund research that supports impact assessment and the design of new measures, studies the need for interventions, and assesses farmers' preferences for adopting the new measures. Attention should be paid to data representing various sustainability issues, especially in the social pillar.

Quantitative analyses are crucial for establishing a causal link between a specific policy intervention and the observed changes. However, when financial resources and available time are limited, qualitative analysis of the contribution can be used to support decision-making. The combination of qualitative and quantitative analyses can significantly improve information and decision-making (Suazo-Galdames *et al.*, 2025). *Ex post* analysis is a key element of policy learning, as information on the effectiveness of measures in achieving goals can and should feed into the next policy cycle.

The impact of science related to agriculture and food systems does not depend solely on the evidence provided by researchers, but also on the demands of decision-makers and practitioners, as well as on coordination between the two sides (McNie, 2007). Effective EBPM is only possible if there is a sufficient supply of evidence that aligns with the needs and expectations of those demanding it, and if the actors are interested in change. A key aspect of the demand for reliable evidence concerns the quality and availability of scientific research, which is essential for building a robust evidence base to address emerging policy challenges. This dynamic is particularly evident in the types of research questions posed within the agricultural domain.

It is important to note that relatively less involvement of quantitative tools does not mean that ministries do not use evidence-based approaches. Many MSs have commissioned targeted research through tenders or directly to research organisations. State research institutes, which exist in at least half of the MSs (e.g., Germany, France, Italy, Ireland, and most eastern-EU MSs), play a role in expert support and analysis with government services. The real challenge is how research support is systematically and comprehensively used in CAP strategic planning in terms of improving it towards evidence-based support. Strategic planning is often treated as a procedural exercise for allocating public funds, both EU and national, rather than as a meaningful process for defining clear strategies aimed at achieving specific goals based on identified needs. This is partly because such strategic depth is not explicitly required, for example through impact assessments.

4.2. Concluding remarks, limitations, and future research

Strategic planning significantly enhances public policies by introducing structured, evidence-based, and goal-oriented approaches to policy design, implementation, and evaluation. With the introduction of comprehensive strategic planning into the CAP after 2023, the necessary first step has been taken towards shaping EU agricultural policy that is more effective and more in line with social needs. Our comparison with evidence-based policymaking criteria has revealed a wide scope for further improvement in planning and, consequently, in future policy. Therefore, it is necessary to take advantage of the systemic change brought about by the integration of the CAP into single national development policy planning.

However, this is not enough to ensure greater integration of scientific principles (EBPM) and participatory approaches into planning. Decision-makers must strengthen the national and regional research infrastructure for strategic planning and reinforce research-based needs assessment. This research should focus on testing the responsiveness and behaviour of potential users when measures are being designed, developing intervention logics supported by studies, impact assessments, and strengthening monitoring. Stronger integration of different knowledge sources – research-based evidence, policy evaluators' expertise, and stakeholders' practical knowledge – can significantly improve strategic planning quality. Importantly, the socially relevant identification of needs and the setting of the policy agenda is a political rather than a technical matter.

There are a few limitations to this paper that must be acknowledged. Our main purpose was to highlight the opportunities for improving the quality of strategic planning that could be brought about by greater consideration of EBPM principles, potentially opening a new area of research in support of agricultural policy decision-making at the EU MS level. Hence, this paper is conceptual, based on desk research and materials from the Tools4CAP research project, which provided a rough picture of the state of strategic planning, but not a more detailed empirical insight into the differences between MSs using developed comparative indicators. New and targeted research is needed to provide more precise and structured direct insights into the quality of CAP strategic planning at the MS level. It is also important to define more precisely the tasks of different scientific disciplines and their integration, policy evaluation and its role, and the contribution of stakeholder participation, with the goal of greater implementation of EBPM in strategic planning. It would be interesting to explore how to systematically – formally and informally – support the role of knowledge and how to further strengthen the dialogue between different social actors in strategic planning.

ACKNOWLEDGEMENT

This work received funding from the EU's Horizon Europe Research and Innovation Programme under Grant Agreement No. 101086311 (Tools4CAP). However, the views and opinions expressed are those of the authors only and do not necessarily reflect those of the EU or the European Research Executive Agency. Neither the EU nor the granting authority can be held responsible for them.

DISCLAIMER

The authors are solely responsible for the content of the paper. The views expressed are purely those of the authors and may not in any circumstances be regarded as stating an official position of the European Commission.

AUTHOR CONTRIBUTIONS

Conceptualization, E.E.; Methodology, E.E., D.B.C.,; Investigation, E.E., I.R, D.B.C.; Writing - Original Draft, E.E., I.R., D.B.C.; Writing –Review & Editing, I.R, D.B.C.; Funding Acquisition, E.E., I.R, D.B.C.; Resources, E.E., I.R, D.B.C.; Supervision, E.E..

REFERENCES

Bryson J., Edwards L.H. (2017). Strategic planning in the public sector. *Oxford Research Encyclopedia of Business and Management*. DOI: https://doi.org/10.1093/acrefore/9780190224851.013.128.

Bryson J.M. (2018). *Strategic Planning for Public and Nonprofit Organizations: A Guide to Strengthening and Sustaining Organizational Achievement* (5th edition). John Wiley & Sons, Inc., Hoboken, NJ, USA.

Bryson J.M., Edwards L.H., Van Slyke D.M. (2018). Getting strategic about strategic planning research. *Public Management Review*, 20(3): 317-339. DOI: https://doi.org/10.1080/14719037.2017.1285111.

Bryson J.M., George B. (2024). *Strategic Planning for Public and Nonprofit Organizations: A Guide to Strengthening and Sustaining Organizational Achievement* (6th edition). John Wiley & Sons, Hoboken, NJ, USA.

Cagliero R., Mazzocchi G., Monteleone A., Pierangeli F., Manzoni di Chiosca P., Romano E. (2022). A participative methodology for prioritising intervention logic in the design of the Italian CAP Strategic Plan. *Italian Review of Agricultural Economics*, 77(3): 25-40. DOI: https://doi.org/10.36253/rea-13717.

Cagliero R., Vassallo M., Pierangeli F., Pupo D'Andrea M.R., Monteleone A., Camaione B., Tarangioli S.

(2023). The Common Agricultural Policy 2023-2027. How do member states implement the new delivery model? *Italian Review of Agricultural Economics*, 78(1): 49-66. DOI: https://doi.org/10.36253/rea-14318.

Cairney P. (2016). *The Politics of Evidence-Based Policy Making.* Palgrave Macmillan UK. DOI: https://doi.org/10.1057/978-1-137-51781-4.

Cairney P. (2019). *Understanding Public Policy: Theories and Issues* (2nd edition). Bloomsbury Academic, London.

Cairney P., Oliver K. (2017). Evidence-based policymaking is not like evidence-based medicine, so how far should you go to bridge the divide between evidence and policy? *Health Research Policy and Systems*, 15(1): 35. DOI: https://doi.org/10.1186/s12961-017-0192-x.

De Castro P., Miglietta P.P., Vecchio Y. (2020). The Common Agricultural Policy 2021-2027: a new history for European agriculture. *Italian Review of Agricultural Economics*, 75(3): 5-12. DOI: https://doi.org/10.13128/rea-12703.

de la Rosa M. (2010). *The Common Agricultural Policy: The Future of the CAP and Why Real Reform Will Never Happen*, European Union Center of Excellence, Miami, FL, USA. https://aei.pitt.edu/44471/1/deLaRosaJrCAPediEUMA.pdf.

Dicks L.V., Hodge I., Randall N.P., Scharlemann J.P.W., Siriwardena G.M., Smith H.G., Smith R.K., Sutherland W.J. (2014). A transparent process for "evidence-informed" policy making: a process for evidence-informed policy making. *Conservation Letters*, 7(2): 119-125. https://doi.org/10.1111/conl.12046.

Dwyer J., Ward N., Lowe P., Baldock D. (2007). European rural development under the Common Agricultural Policy's 'second pillar': institutional conservatism and innovation. *Regional Studies*, 41(7): 873-888. DOI: https://doi.org/10.1080/00343400601142795.

El Benni N., Grovermann C., Finger R. (2023). Towards more evidence-based agricultural and food policies. *Q Open*, 3(3), qoad003. DOI: https://doi.org/10.1093/qopen/qoad003.

Erjavec E., Rac I. (2023). Improving the quality of CAP strategic planning through enhancing the role of agricultural economics. *EuroChoices*, 22(2): 71-76. DOI: https://doi.org/10.1111/1746-692X.12393.

EU CAP Network (2023). *Synthesis of ex ante evaluations of CAP post 2020*, Brussels. https://eu-cap-network.ec.europa.eu/publications/synthesis-ex-ante-evaluations-cap-post-2020_en.

European Commission (2020). *Communication from The Commission to the European Parliament, The Council, The European Economic and Social Committee and the Committee of the Regions. Recommendations to the Member States as Regards Their Strategic Plan for the Common Agricultural Policy*, COM/2020/846 final (2020), Brussels. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex:52020DC0846.

European Commission (2023a). *Report from the Commission to the European Parliament and the Council: Summary of CAP Strategic Plans for 2023-2027: Joint Effort and Collective Ambition*, Brussels. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex:52023DC0707.

European Commission (2023b). *Mapping and Analysis of CAP Strategic Plans. Assessment of joint efforts for 2023-27*, Brussels. https://agriculture.ec.europa.eu/common-agricultural-policy/cap-overview/cmef/regulation-and-simplification/mapping-and-analysis-cap-strategic-plans_en.

European Commission (2025a). *Proposal for a REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL establishing a budget expenditure tracking and performance framework and other horizontal rules for the Union programmes and activities*, COM/2025/545, Brussels. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52025PC0545&qid=1762364884931.

European Commission (2025b). *Proposal for a REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL Establishing the Conditions for the Implementation of the Union Support to the Common Agriculture Policy for the Period from 2028 to 2034*, COM/2025/560, Brussels. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex:52025PC0560.

European Commission (2025c). *Proposal for a REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL establishing the European Fund for economic, social and territorial cohesion, agriculture and rural, fisheries and maritime, prosperity and security for the period 2028-2034 and amending Regulation (EU) 2023/955 and Regulation (EU, Euratom) 2024/2509*, COM/2025/565, Brussels. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex:52025PC0565.

European Court of Auditors (2024). *Special report 20/2024: Common Agricultural Policy Plans – Greener, but not matching the EU's ambitions for the climate and the environment*, No. 20/2024, Brussels. https://www.eca.europa.eu/en/publications/sr-2024-20.

Folkeson C., Valli C., Avis K., Rouillard J., Underwood E., Parissaki M., Bertolozzi Caredio D., Devot A. (2024). *Mapping and Analysis of CAP Strategic Plans*, Publications Office of the European Union, Brussels. DOI: https://doi.org/10.2762/71556.

Hepping S., Breeman G., Vijver M.G. (2025). A CAP on ambitions: Power, fragmentation, and the struggle for transformative policy in the post-2022 common agricultural policy debates. *NJAS: Impact in Agricultural and Life Sciences*, 97(1), 2521262. DOI: https://doi.org/10.1080/27685241.2025.2521262.

Howlett M. (2018). The contexts and components of policy design: Governance modes and policy regimes. In Howlett M., Mukherjee I. (eds) *Routledge Handbook of Policy Design* (pp. 20-33). Routledge, London.

Howlett M., Mukherjee I. (2018). *Routledge Handbook of Policy Design*. Routledge, London.

Hudson B., Hunter D., Peckham S. (2019). Policy failure and the policy-implementation gap: can policy support programs help? *Policy Design and Practice*, 2(1): 1-14. DOI: https://doi.org/10.1080/25741292.2018.1540378.

Johnsen Å. (2015). Strategic management thinking and practice in the public sector: a strategic planning for all seasons? *Financial Accountability & Management*, 31(3): 243-268.

Mayne J. (2007). Challenges and lessons in implementing results-based management. *Evaluation*, 13(1): 87-109. DOI: https://doi.org/10.1177/1356389007073683.

McNie E.C. (2007). Reconciling the supply of scientific information with user demands: an analysis of the problem and review of the literature. *Environmental Science & Policy*, 10(1): 17-38. DOI: https://doi.org/10.1016/j.envsci.2006.10.004.

Mezzacapo E. (2024). Mind the gap: assessing MSs' implementation of farm to farm-to-fork targets within the 2023–2027 common agricultural policy. *European Journal of Risk Regulation*, 15(2): 265-279. DOI: https://doi.org/10.1017/err.2024.44.

Munch A., Badouix M., Gorny H., Messinger I., Schuh B., Brkanovic S., Monika B., Bodart S., Van Bunnen P., Runge T. (2023). *Research for AGRI Committee-Comparative analysis of the CAP Strategic Plans and their effective contribution to the achievement of the EU objectives*, Publications Office of the European Union, Brussels. https://www.europarl.europa.eu/RegData/etudes/STUD/2023/747255/IPOL_STU(2023)747255_EN.pdf.

Organisation for Economic Co-operation and Development (2020). *Strengthening Governance of EU Funds under Cohesion Policy: Administrative Capacity Building Roadmaps*, OECD Publishing, Paris. DOI: https://doi.org/10.1787/9b71c8d8-en.

Organisation for Economic Co-ordination and Development (2024). *Social issues in agriculture in rural areas*, OECD Food, Agriculture and Fisheries Papers No. 212, OECD Publishing, Paris. DOI: https://doi.org/10.1787/fec15b38-en.

Poister T.H. (2010). The future of strategic planning in the public sector: linking strategic management and performance. *Public Administration Review*, 70(s1). DOI: https://doi.org/10.1111/j.1540-6210.2010.02284.x.

Poister T.H., Streib G.D. (1999). Strategic management in the public sector: concepts, models, and processes. *Public Productivity & Management Review*, 22(3): 308-325. DOI: https://doi.org/10.2307/3380706.

Popp T.R., Feindt P.H., Daedlow K. (2021). Policy feedback and lock-in effects of new agricultural policy instruments: a qualitative comparative analysis of support for financial risk management tools in OECD countries. *Land Use Policy*, 103, 105313. DOI: https://doi.org/10.1016/j.landusepol.2021.105313.

Rondinelli D.A. (1976). Public planning and political strategy. *Long Range Planning*, 9(2): 75-82.

Runge T., Latacz-Lohmann U., Schaller L., Todorova K., Daugbjerg C., Termansen M., Liira J., Le Gloux F., Dupraz P., Leppanen J., Fogarasi J., Vigh E.Z., Bradfield T., Hennessy T., Targetti S., Viaggi D., Berzina I., Schulp C., Majewski E., Bouriaud L., Baciu G., Prokofieva I., Velazquez F.J.B. (2022). Implementation of eco-schemes in fifteen European Union MSs. *EuroChoices*, 21: 19-27. DOI: https://doi.org/10.1111/1746-692X.12352.

Sanderson I. (2002). Evaluation, policy learning and evidence-based policy making. *Public Administration*, 80(1): 1-22. DOI: https://doi.org/10.1111/1467-9299.00292.

Strydom W.F., Funke N., Nienaber S., Nortje K., Steyn M. (2010). Evidence-based policymaking: a review. *South African Journal of Science*, 106(5/6): 1-8. DOI: https://doi.org/10.4102/sajs.v106i5/6.249.

Suazo-Galdames I.C., Saracostti M., Chaple-Gil A.M. (2025). Scientific evidence and public policy: a systematic review of barriers and enablers for evidence-informed decision. *Frontiers in Communication*, 10, 1632305. DOI: https://doi.org/10.3389/fcomm.2025.1632305.

Termeer C.J.A.M., Werkman R.A. (2011). Changing closed agricultural policy communities. *Critical Policy Studies*, 5(3): 283-298. DOI: https://doi.org/10.1080/19460171.2011.606301.

Tools4CAP Consortium (2023a). *Deliverable D1.1: Inventory of methods & tools used by MSs*, Horizon Europe Project Tools4CAP (Grant Agreement No. 101086311). https://www.tools4cap.eu/wp-content/uploads/2023/10/D1.1-Inventory-of-methods-and-tools.pdf

Tools4CAP Consortium (2023b). *Deliverable D1.2: Tools-4CAP conceptual framework*, Horizon Europe Project

Tools4CAP (Grant Agreement No. 101086311). https://www.tools4cap.eu/wp-content/uploads/2023/10/D1.2-Conceptual-framework.pdf.

Tools4CAP Consortium (2024a). *Deliverable D1.4: Inventory of methods & tools used by MSs – Extended version*, Horizon Europe Project Tools4CAP (Grant Agreement No. 101086311). https://www.tools4cap.eu/wp-content/uploads/2025/03/D1.4-Inventory-of-methods-tools-used-by-MSs-II.pdf.

Tools4CAP Consortium (2024b). *Deliverable 6.5: Summary report and analysis of the first-round focus groups*, Horizon Europe Project Tools4CAP (Grant Agreement No. 101086311). https://www.tools4cap.eu/wp-content/uploads/2024/03/D6.5-Analysis-of-first-round-focus-groups.pdf.

Tools4CAP Consortium (2024c). *Deliverable 1.3: Evaluation of methods and tools*, Horizon Europe Project Tools4CAP (Grant Agreement No. 101086311). *Tools4CAP_Evaluation-and-benchmarking-of-methods-and-tools-D1.3.pdf

Weiss C.H. (1998). *Evaluation: Methods for Studying Programs and Policies*. Prentice Hall, Upper Saddle River, NJ, USA.

REA | ITALIAN REVIEW OF AGRICULTURAL ECONOMICS

Firenze University Press
www.fupress.com/rea

OPEN ACCESS

Citation: Pupo D'Andrea, M. R., Carillo, F., Scardera, A., & Henke, R. (2025). The Common Agricultural Policy and income disparities in Italian agriculture. *Italian Review of Agricultural Economics* 80(3): 23-42. DOI: 10.36253/rea-16643

Received: July 31, 2025

Revised: November 25, 2025

Accepted: December 5, 2025

Data Availability Statement: Data will be made available by the corresponding author upon request.

Competing Interests: The Author(s) declare(s) no conflict of interest.

Guest Editor: Francesco Mantino

ORCID
MRPDA: 0000-0003-0635-1509
FC: 0000-0003-1442-0973
AS: 0000-0001-9853-2678
RH: 0000-0003-1677-0387

Research article

The Common Agricultural Policy and income disparities in Italian agriculture

Maria Rosaria Pupo D'Andrea, Felicetta Carillo, Alfonso Scardera, Roberto Henke*

CREA – Research Centre for Agricultural Policies and Bioeconomy, Italy
*Corresponding author. E-mail: roberto.henke@crea.gov.it

Abstract. This paper investigates the persistence of territorial disparities in agricultural income across Italian macro-regions, with a particular focus on the role of the Common Agricultural Policy (CAP). Drawing on the Italian Farm Accountancy Data Network (FADN) dataset, this study develops and applies a set of income indicators to examine whether CAP support has contributed to narrowing or widening regional agricultural income gaps at the farm level. The results confirm that despite the redistribution efforts embedded in the CAP, especially through the internal convergence mechanism, the agricultural income gap between North and South Italy has persisted and, in some cases, widened. Regression analyses at the farm level reveal that CAP support, though relatively higher in South Italy, has not sufficiently counterbalanced the lower market-based income. The findings suggest that while the CAP is not designed as a redistributive instrument, it has had a limited impact on fostering income convergence in agriculture. These results underscore the need for a more integrated and place-based policy mix to promote balanced development and to foster fair development in rural areas.

Keywords: farm income, CAP, Mezzogiorno, agricultural disparities, FADN.
JEL codes: Q12, Q18, R11.

HIGHLIGHTS

- The design of the new CAP is more place-based than before, yet territorial agricultural income disparities persist at both macro and micro levels.
- South Italy shows persistently lower farm incomes despite higher support.
- CAP support has not significantly reduced macro-regional agricultural income gaps.
- In South Italy, a gap in farm value added and labour productivity persists.

1. INTRODUCTION

Since its inception, the Common Agricultural Policy (CAP) has undergone significant changes to better align with the objectives set out in the

European Union (EU) treaties. In doing so, the European Commission has progressively moved from a centralised mode of intervention to a CAP closer and more targeted to the different territories of an EU which has grown significantly (Frascarelli *et al*., 2025; Greer, 2017; Guyomard *et al*., 2024; Henke *et al*., 2018). The 2023-2027 CAP reform further extended and organised the CAP goals into 10 Specific Objectives (SOs) addressing the three pillars of sustainability: economic, environmental, and social. The CAP instruments have been organised into a single programming document, the CAP Strategic Plan (CSP), which is drawn up by each Member State (MS).

These changes have transformed the CAP from a single, centralised, top-down policy for all MSs ("one size fits all") to a multidimensional policy that specifically addresses the diverse European rural territories according to a place-based approach. Although this approach does not openly declare such an intention, it nonetheless acknowledges the diversity of agricultural and rural contexts within the EU and individual MSs (Chmieliński *et al*., 2025; Crescenzi *et al*., 2015; Duhr *et al*., 2010; Mantino *et al*., 2022). This has been made possible by a greater degree of flexibility, enabling MSs to adapt the relevant policy tools to the specificity of their agriculture and rural territories within a common framework (Henke *et al*., 2018).

Although the CAP was never intended to be a redistributive policy aimed at addressing territorial disparities in agriculture (Alexiadis *et al*., 2013; Shucksmith *et al*., 2005), its evolution has resulted in a significant expansion of its objectives, with an increasing focus on the resilience of the primary sector, fairer income and financial support distribution, and improving the quality of life in rural and disadvantaged areas (Giannakis, Bruggeman, 2020; Shucksmith *et al*., 2009). Within the second pillar of the CAP, the measures explicitly focus on improving living conditions in rural territories, overtaking the traditional centre-periphery opposition and promoting balanced economic and social development within environmental boundaries (Salvati *et al*., 2017; Uthes, Herrera, 2019). In contrast, support via the first pillar is secured through a direct payment system, which in turn redefines income distribution at the sectoral and territorial levels (Dinis, 2024; Ilies *et al*., 2023).

In recent years, Italy has been a large beneficiary of EU support through the CAP and the Cohesion Policy, which aims to reduce territorial disparities across the EU's regions (Molica, Santos, 2025), with South Italy (called frequently "Mezzogiorno") receiving a large portion of the resources, given the gap in most economic and social indicators (Mingo, 2023). This is not a novel condition: after the Second World War and even before the EU had been founded, there had been a "Mezzogiorno problem" as part of centre-periphery dualistic development, which has diverted generous resources towards that part of the country, with the main goal of filling, or at least reducing, the development gap (Dean *et al*., 1972; Giannola, 2009; Lepore, 2012). Agriculture was definitely part of the financial project, so the sectoral income gap, originally identified as a national "agricultural problem", progressively turned into a focus on South Italy.

The persistence of the discrepancy in regional economic development between North and South Italy has led scholars to investigate this lagging condition despite specific public support (Barca, 2001; Daniele, 2021; Giarda, Moroni, 2018; Iuzzolino *et al*., 2011; Podbielski, 1981; Salvati *et al*., 2017; Watson, 1970). This phenomenon is often described internationally as the "Mezzogiorno trap", which is a specific feature of the more general "Mezzogiorno problem". The Mezzogiorno trap refers to regions that depend on external support, rather than internal economic activities, to reduce their development gap with more advanced areas. However, disparities re-emerge and widen in the absence of such support, perpetuating a cycle of underdevelopment (Li *et al*., 2023; Molica, Santos, 2025). The Mezzogiorno trap has become emblematic of South Italy, but similar phenomena have been observed in other parts of the world, such as in Germany after reunification; the Rust Belt in the United States, where industry has declined; and, more recently, remote regions of China (Li *et al*., 2023).

The Mezzogiorno trap refers especially to economic aspects. However, it affects social and environmental conditions, highlighting situations of social injustice and differentiated impacts of pollution and territorial degradation on the population. These impacts are primarily related to disparities in quality of life in rural areas and services offered to the local population (Bartolini, Pagliacci, 2017; Camarero, Oliva, 2019; Mihai, Iatu, 2020). In the case of the CAP, these dynamics are reinforced by the multidimensional and multiscope nature of the policy itself, which acts as a multiplier on the links among sectors and territories (Dumangane *et al*., 2021; Papadopoulos, 2015).

Over time, and especially in light of the average positive response in Italy to CAP and other EU support, the lagging development of regions in South Italy and the gap with the rest of the country have been neglected. This has happened in favour of the growth of Italy in the European context. Consequently, the concept of Italy's two-tier development has not only been accepted as an inevitable condition, but has also largely been overlooked in most studies and reports, despite the occasional national or local voice attempting to highlight the paradox of South Italy and the growing gap with the rest of the country (Accetturo *et al*., 2022; De Filippis, Henke, 2014; Fabiani, Henke, 2020; ISMEA, Svimez, 2017; Quadro Curzio, Fortis, 2014).

The income gap between farm and non-farm households in rural and non-rural areas is well documented and has been widely investigated (Marino *et al*., 2024; Meloni *et al*., 2024). The persistence of this gap in Italy, where the average agricultural income is lower than that of the rest of the economy, is the basis for national choices to achieve SO1 (support viable farm income and the resilience of the agricultural sector across the EU) within the national 2023-2027 CSP. Fewer studies have focused on the agricultural income gaps at the regional level in Italy, dealing especially with the effects of rural development policies (Mantino *et al*., 2022).

In this paper, we aim to address this research gap by highlighting the ongoing disparity in agricultural income at the farm level between Italy's different macro-regions (i.e., North, Centre, and South). More specifically, we investigate how this disparity has evolved over time and the influence of CAP support (both pillars) on this trend. Has it contributed to reduce this gap, or has it, perhaps unintentionally, increased it?

We examine the CAP programming period 2014-2022, using data from the Italian Farm Accountancy Data Network (FADN). During this period, a process of gradual equalisation in the distribution of CAP direct payments among farmers was initiated. As an indirect consequence of this measure, resources have been shifted from lowland areas with intensive agriculture to mountainous areas, marginal rural areas, and peripheral and ultra-peripheral inland areas (Pierangeli *et al*., 2025). This trend has been strengthened by Italy's 2023-2027 CSP, which emphasises what was already in place in the previous programming periods about local development, institutionalising the involvement of economic, social and environmental stakeholders along a scheme of participative approach (Henke *et al*., 2025; Pierangeli *et al*., 2023, 2025).

The objective of this study is twofold. First, we investigate the persistence of territorial agricultural income gaps between the Italian Mezzogiorno and the rest of the country, and to analyse, through the calculation of a specific indicator, whether the two components of agricultural income – market income and CAP support – move in the same or opposite directions. Second, we aim to determine whether the gaps that emerge at the level of the entire agricultural sector stand out at the farm level, and the role played by CAP support of both pillars. We estimate average performance measures for farms located in the different Italian macro-regions. Specifically, using several regression models, we predict farm profitability through variables representing macro-regional fixed effects, including some farm characteristics (size and production specialisation), to control for individual fixed effects.

The remainder of the article is structured as follows. Section 2 provides a review of the literature investigating the linkages between the CAP and territorial disparities in agricultural income. Section 3 presents the methodology and data used in our analysis. Section 4 presents the results of our analyses aimed at identifying the existence of an agricultural income gap at the Italian macro-regional level, examining the role of CAP subsidies at the farm level. Section 5 discusses these results. Finally, Section 6 concludes the paper and explores policy implications and future developments of the research.

2. LITERATURE REVIEW

Many contributions on income gaps in Europe and Italy focus on regional policies and Cohesion Funds, and deal only marginally with the CAP. The analysis of the role of the CAP in reducing economic disparities between territories has usually been confined, for legitimate reasons, to the policies with a more genuine territorial approach and objectives, such as the rural development policies. There has been much less research dealing with the first pillar of the CAP and, specifically, direct payments, which represent by far the largest share of resources devoted to farmers and landing in rural areas. It is worth noting that, despite a rather stable structure and set of goals for the CAP, the tools have changed, and the policy has progressively become more place-based, greener, and tailored and targeted towards territories and the actors involved. However, most recent analyses have focused more on environmental and sectoral effects rather than territorial development and income gaps (De Castro *et al*., 2020; Guyomard *et al*., 2023). For this reason, even if the issue of income gaps has never been clearly mentioned in the set of the CAP goals, the impacts of the different measures implemented have had varying intensity on such gaps (Frascarelli *et al*., 2025; Hill, 2008; Pierangeli *et al*., 2025). Moreover, the organisation of tools into pillars after 1999 has somehow increased attention to this issue, because the second pillar pays explicit attention to territorial disparities and shows more similarities with the Cohesion Policy than the first pillar of the CAP, both in its theoretical approach and instruments (Dax, 2006; Dwyer *et al*., 2006). In any case, the findings vary significantly depending on several factors: the territorial scale of the analysis, the variables under examination, the period considered, and whether the CAP is examined in isolation (and which pillar it refers to) or alongside structural policies.

Lillemets *et al*. (2022) reviewed the literature on the impact of the CAP on the socioeconomic condition in the EU's rural areas. Limited or no conclusive evidence emerges from studies when the focus is on regional cohesion. According to Crescenzi, Giua (2016), "spatially blind" measures (i.e., those applied uniformly across the territory) appear to foster growth in the most disadvantaged and peripheral regions, while spatially targeted rural development measures have a positive influence only in the most advanced regions. In terms of spillover effects, studies have shown that CAP funds – although primarily aimed at the agricultural sector and rural areas – affect the entire economy, demonstrating greater effectiveness and efficiency in developed regions, with economic effects spilling over into wealthier urban areas (Bonfiglio *et al*., 2016; Montresor *et al*., 2011). Esposti (2007) investigated the impact of both the CAP and structural policies on European regions and found that the CAP positively impacts the convergence process but with negligible effects, sometimes conflicting with structural policies that aim to promote growth in lagging regions. Crescenzi, Giua (2014) looked at the impact of the Cohesion Policy and the first and second pillars of the CAP in 139 European regions (Nomenclature of Territorial Units for Statistics, level 2 [NUTS2]) in 12 MSs and showed how regional and agricultural policies work together in favour of regional economic growth. When looking at the effect of the single policies, the authors highlighted how the effects of each pillar of the CAP depend greatly on the starting points of the local contexts. In more dynamic areas, rural development resources also seem to contribute significantly to growth. In less developed areas, some positive effects can be connected to the first pillar measures (which have no links to the development rate of areas), which do not require bottom-up planning but are rather top-down directed to territories. In their detailed review on the coherence of EU policies, Mikuš *et al*. (2019) emphasised the need for better coordination of top-down and bottom-up policies to focus more efficiently on economically disadvantaged areas and thus to reduce territorial gaps and improve cohesion in Europe. Crescenzi, De Filippis (2016) and Crescenzi *et al*. (2015) highlighted the importance of better designing and implementing all the policies addressing economic development in less-developed regions to effectively allocate resources through appropriate place-based allocation mechanisms. Similarly, Calegari *et al*. (2021) suggested combined financing of both policies in developing regions to boost convergence. The Organisation for Economic Co-ordination and Development (OECD, 2021) also advocated greater coordination and complementarity between CAP rural development measures and the Cohesion Policy, given the importance of the agricultural sector in developing regions.

More recently, Chmieliński *et al*. (2025) analysed the relationship between the Cohesion Policy and the first pillar of the CAP in the 2007-2013 programming period and identified cases where synergies or conflicts occur when these policies overlap within the same region. The authors found that in structurally disadvantaged regions, the two policies work jointly towards regional development goals. Although the extent of positive spillovers between the policies remains to be assessed, the authors concluded that a relevant factor in explaining how funds are absorbed is the specificity of the region or its specialisation.

Another stream of the literature has shed light on the disparities in the distribution of funds, which increase, rather than reduce, regional imbalances and limit the effectiveness of funds in promoting a fairer regional development. Based on their evaluation of trends and gaps among MSs, Manta *et al*. (2024) highlighted several divergences, both in terms of resource distribution (first and second pillar) and the impact on regional development. The authors identified three types of variables to explain the regional disparities – economic diversification, institutional capacity, and geographical accessibility – and they added human capital, historical disadvantages, and the way public intervention is planned and implemented. The authors stressed the persistence of territorial disparities, despite the generous financial support of development funds, due to the unequal distribution of resources and their diversified regional impact. Martínez García *et al*. (2024) focused on demographic aspects in Extremadura (Spain) and showed how CAP support tends to favour more dynamic territories rather than remote and marginalised ones, leaving these areas behind. On the contrary, Galluzzo (2021) explored the impact of CAP support (the first and second pillars) on the reduction of the level of poverty and emigration and found a positive and significant impact of CAP subsidies allocated under both pillars in reducing marginalisation in Romanian rural areas. In evaluating the impact of the CAP on the territorial development of rural areas, the European Commission (2021) also found that both pillars have had a positive effect in promoting balanced territorial development. However, improvements in socioeconomic conditions and social inclusion depend on the specific characteristics of each rural region and the mix of policies implemented. Hansen, Teuber (2011) provided a more nuanced conclusion. They compared farmers' revenues and disposable income, with and without the CAP, for two different periods at the sub-regional level in Germany. The findings revealed that the CAP tends to attenuate differences in agricultural incomes across regions but does not prevent significant divergence over time. Additionally, CAP transfers reduce inequality in per capita disposable income across regions within society as a whole, but their impact on regional convergence is negligible.

Hansen, Herrmann (2012) reviewed the contribution of the CAP impact on territorial cohesion and highlighted ambiguity in the results. These studies refer to the "old" CAP, prior to the decoupling of support implemented with the 2013 reform (Anders *et al*., 2007; Bivand, Brunstad, 2003, 2006; Esposti, 2007; European Commission, 2001; Hansen, Teuber, 2011; Shucksmith *et al*., 2005; Tarditi, Zanias, 2001). Hansen, Herrmann (2012) were able to explain the dissimilarity in the results by developing a conceptual framework for assessing the policy impacts of the CAP on economic cohesion that distinguishes between the redistributive impact at a defined time and the change in redistribution impact over time. Based on an analysis of the 1991-2009 period in 13 German regions, they concluded that while the CAP reduces territorial disparities each year, it does not affect income convergence for society as a whole over time.

In this work, we have reviewed studies that reflect a wide range of approaches to the issue of the CAP and agricultural income gaps. However, to our knowledge, recent research has not addressed disparities across Italian macro-regions, particularly the so-called Mezzogiorno trap. We aim to fill this gap by examining the existence and evolution of agricultural income differences at both the macro-regional and farm levels in Italy, focusing specifically on South Italy compared with the rest of the country, and assessing the extent to which CAP support from both pillars influences these disparities.

3. METHODOLOGY AND DATA

Disparities in agricultural income at the sectoral level are commonly analysed through three indicators, elaborated by Eurostat and defined in the Economic Accounts for Agriculture (EAA)[1]. The EAA offers detailed information on agricultural performance and income at the national (NUTS1) and regional (NUTS2) levels; however, at the regional level, the data are only available at current prices. The EAA provide a wide range of variables on the economic activities in the agricultural sector. These include output, intermediate consumption, gross and net value added, gross fixed capital formation (GFCF), compensation of employees, other taxes and subsidies on production, net operating surplus or net mixed income, property income, and net entrepreneurial income.

The three indicators of agricultural income defined in EAA Regulation 138/2004 are:

- Indicator A: index of the real income of factors in agricultural per annual work unit (AWU), corresponding to the real net value added at factor cost of agriculture per total AWU;
- Indicator B: index of real net agricultural entrepreneurial income per unpaid annual work unit, presenting the changes in net entrepreneurial income over time, per non-salaried AWU;
- Indicator C: net entrepreneurial income of agriculture, an income aggregate presented as an absolute value (or in the form of an index in real terms), allowing comparability over time of the income of the agricultural sector between MSs.

These indicators are calculated at the national and, where possible, regional levels. They are used to analyse the trend of agricultural income performance of an MS over time or to compare performance between MSs (Andrei *et al*., 2023; Eurostat, 2018; Kiss, 2020; Matthews, 2024; Runowski, 2020; Schmid *et al*., 2006).

To identify the presence of an income gap between geographical macro-regions in Italy – North, Centre, and South – we calculated values at the sub-national level using FADN data as weighted averages (Cirianni *et al*., 2021). Furthermore, to highlight the role of the CAP in agricultural income, we separated the CAP support included in the operating account from the net farm income, resulting in the calculation of Indicator D, namely net farm income, which is the net support[2] granted on an operating account basis. We calculated this indicator only based on the Italian FADN survey data, and this calculation applies only within the scope of the analyses conducted in this study. We carried out this new analysis based on the study by Coppola *et al.* (2020), who showed how public support affects farms' economic outcomes.

[1] The EAA are a satellite account of the European System of Accounts (ESA). Regulation (EC) No 138/2004. National Statistical Institutes or Ministries of Agriculture are responsible for data collection and calculation of national EAA, in accordance with European Commission regulations. Eurostat is responsible for the EU aggregations.

[2] CAP support includes all funding provided by the CAP, such as direct support, market measures, and rural development, during the 2014-2022 programming period. Table A.1 in the Appendix provides the details for all aid considered in this study.

To assess the robustness of our data, we compared Indicators A, B, and C, calculated using the FADN data at the national level, with the values calculated by Eurostat from 2014 to 2022. We set the nominal values to 100 to highlight the observed deviations more easily.

We performed four ordinary least squares regressions to characterise the trends in the agricultural income gap at the farm level. The first two estimated the changes in the differences in the average agricultural incomes between farms belonging to the Italian macro-regions, which emerged before and after the 2014-2022 CAP programming period. The other two regressions estimated the changes in the CAP subsidies received by farms in the same years.

We used the Italian FADN 2014 data as a baseline, and the 2022 data to estimate differences in the dependent variables. For both years, the FADN samples, representative of regional agriculture, comprise approximately 11,000 farms. Overall, the dataset includes 21,657 observations.

The dependent variables are the farm net value added (FNVA)[3], the FNVA per AWU, the annual CAP support and the CAP support per AWU. The explanatory variables for all regressions are described below. We included a dichotomous variable (year), with a value of 0 for the year 2014 and 1 for the year 2022, to capture how the dependent variable increases or decreases over time. Our variable of interest is a categorical variable indicating whether the farm is North, Central, or South Italy. By multiplying this categorical variable by the year variable, we can estimate how the conditional means of the dependent variables vary by farm location in each year (2014 and 2022). Therefore, the difference between the coefficients in the years informs us whether the gaps between the macro-regions have increased, decreased, or remained the same.

We considered sector fixed effects in the model by using a categorical variable that indicates whether a farm specialises in arable crops, permanent crops, livestock, or mixed production. The economic size of the farm is also included as an explanatory variable to control for differences in farm characteristics. Farms were classified as small (Standard Output [SO][4] 8,000-25,000 euros), medium (SO 25,001-100,000 euros), or large (SO > 100,000 euros), corresponding to a value equal to 1, 2, and 3, respectively.

[3] FNVA = output + pillar I and annual pillar II payments + any national subsidies + VAT balance − intermediate consumption − farm taxes (income taxes are not included) − depreciation.

[4] SO is the regional average monetary value of agricultural output at the farm-gate price, per hectare or per head of livestock. The total SO per farm, calculated by summing the SO per hectare of crops and per head of livestock, was used to measure the farm's overall economic size.

The variable CAP support, expressed in euros, measures the effects of public support on the FNVA level. We used it to estimate, through our variable of interest, the net gap per farm and per AWU, which depends on the market.

We estimated a weighted regression model using farm-level data, where weights represent the expansion factors used to project the sample to the reference population. Finally, the standard errors are clustered at the regional level to account for the potential within-region correlation of residuals. It is worth noting that the model is designed to estimate the changes in agricultural income differences between macro-regions over time, controlling for farm size, CAP support, and productive specialisation. While our analysis focuses on these conditional differences, it does not aim to identify causal effects of CAP support or other control variables. However, some limitations of the analysis should be noted. The analysis relies on only two years (2014 and 2022), which limits the ability to capture intermediate trends or to distinguish temporary from persistent changes in regional agricultural income differences. Moreover, while the model controls for CAP support, farm size, and sectoral specialisation, these variables are not interpreted causally; the interaction between Year and macro-region reflects conditional differences rather than causal effects.

4. RESULTS

4.1. The gap in agricultural income at the Italian subnational level

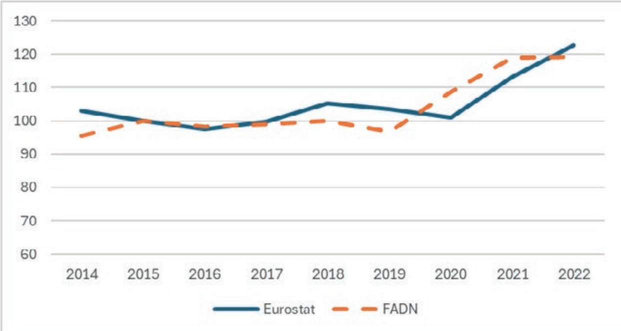
Based on Eurostat and FADN data, Indicator A remained stable until 2020 and then increased over the following two years, reaching a level approximately 20% higher than its 2015 value (Figure 1)[5]. A similar trend was observed for Indicator B, which increased by around 25% according to both data sources (Figure 2).

We noted a small discrepancy between the two data sources in the final years of the 2014-2022 period with respect to Indicator C (Figure 3). Based on the EAA data, profitability remained essentially stable, whereas the FADN data indicated an increase of more than 20%, consistent with the patterns observed for Indicators A and B.

What additional insights do the FADN data provide on territorial disparities in agricultural income and the role of CAP support? The geographical breakdown of

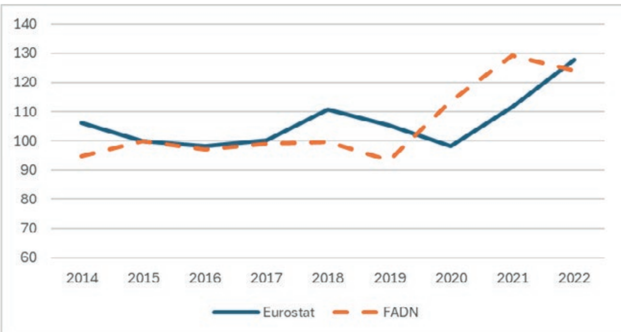
[5] The absolute values of the indicators are reported in Table A.2 in the Appendix.

Figure 1. Trend of Indicator A (index of the real income of factors in agriculture per annual work unit) over time.



Note: the data are presented relative to 2015, which was set at 100.
Source: Eurostat (2025) and authors' elaborations based on the Italian Farm Accountancy Data Network (FADN) dataset for 2014-2022.

Figure 2. Trend of Indicator B (index of the real net agricultural entrepreneurial income, per unpaid annual work unit) over time.

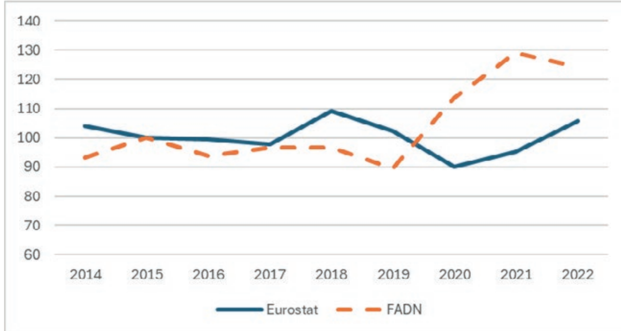


Note: the data are presented relative to 2015, which was set at 100.
Source: Eurostat (2025) and authors' elaborations based on the Italian Farm Accountancy Data Network (FADN) dataset for 2014-2022.

the FADN data shows increasing remuneration of farm work units – both overall (Indicator A) and for family work component specifically (Indicator B) – favouring the North and Central Italy relatively to South Italy (Figure 4).

Over the analysed period, the gap between the three major Italian macro-regions in terms of farm profitability, as indicated by Indicator C, has widened (Figure 5). The decline in profitability observed until 2019, linked to the global economic crisis that also affected Italy, was followed by a period of growth. This growth was particularly strong in North Italy, where profitability increased by over 40% compared with 2015. In Central Italy, the increase was more moderate (around 25%) and only became evident in 2022. In contrast, after experiencing growth in 2020 and 2021, in 2022 farm profitability in South Italy returned to the same levels as in 2015.

Figure 3. Trend of Indicator C (net entrepreneurial income of agriculture) over time.



Note: the data are presented relative to 2015, which was set at 100.
Source: Eurostat (2025) and authors' elaborations based on the Italian Farm Accountancy Data Network (FADN) dataset for 2014-2022.

When separating the component of CAP support granted for production (excluding investment aid)[6] from net farm income (Indicator D), CAP support seems to have little to no influence in reducing geographical agricultural income disparities through farm profitability support (Figure 6). In fact, across all three Italian macro-regions, the trend in CAP support is very similar, with deviations limited to just a few percentage points, clearly insufficient to balance out the recorded agricultural income gaps. Moreover, in certain cases, such as in 2020, public support even increased in North Italy, precisely where agricultural income was also rising.

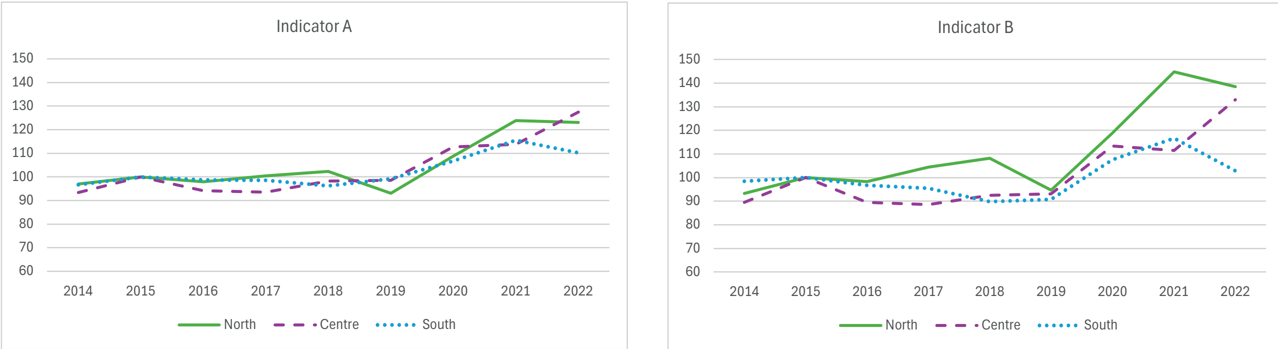
4.2. The agricultural income gap and the role of the CAP at the farm level

Table 1 presents descriptive statistics for 2014 and 2022 on the structural composition of the sample and key farm performance indicators utilised in the analysis. The FADN sample is relatively balanced over time, with around 10,500 observations in 2014 and 11,000 in 2022. North Italy consistently accounts for the largest share of farms, followed by South and Central Italy. This reflects the actual geographical distribution of Italian agriculture, confirming that these data are representative and useful for comparison.

The composition by farm type shows evident regional specialisation: arable crops dominate in Central Italy, while permanent crops are concentrated in South Italy.

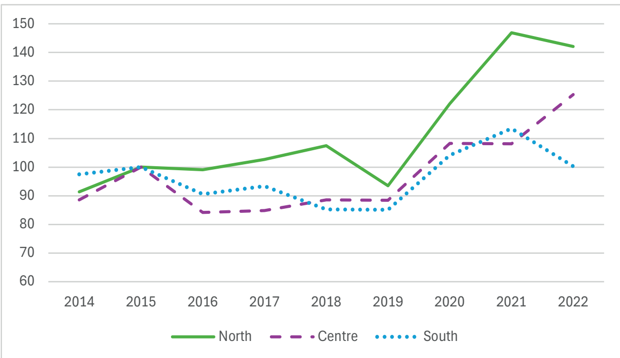
[6] Although the investment aid is a big booster of profitability, we did not include it because of a time lag between when the aid was received and when the benefit was realised. Moreover, investment aid follows an irregular flow that depends on the progress of the project and the payment capacity of the providing institution.

Figure 4. Geographical trend of Indicator A (index of the real income of factors in agriculture per annual work unit) and Indicator B (index of real net agricultural entrepreneurial income, per unpaid annual work unit) over time.



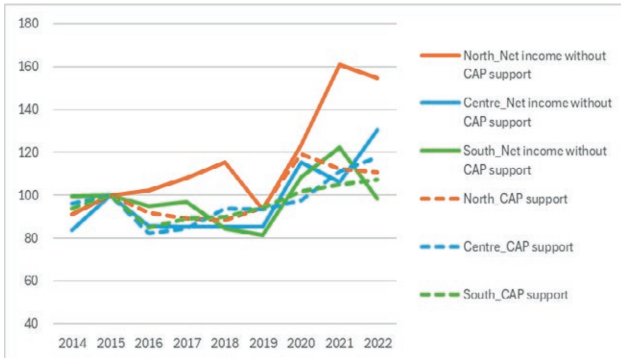
Note: the data are presented relative to 2015, which was set at 100.
Source: authors' elaborations based on the Italian Farm Accountancy Data Network (FADN) dataset for 2014-2022.

Figure 5. Geographical trend of Indicator C (net entrepreneurial income of agriculture) over time.



Note: the data are presented relative to 2015, which was set at 100.
Source: authors' elaborations on the Italian Farm Accountancy Data Network (FADN) dataset for 2014-2022.

Figure 6. Geographical trend of Indicator D (net entrepreneurial income of agriculture, net of CAP support) over time.



Note: the data are presented relative to 2015, which was set at 100.
Source: authors' elaborations on the Italian Farm Accountancy Data Network (FADN) dataset for 2014-2022.

North Italy maintains a more diversified structure, with a notable presence of livestock farms. There are also differences in farm size, with large farms more common in North Italy (41% in 2022) and smaller farms relatively more frequent in South Italy (25%), highlighting structural asymmetries.

In terms of economic performance, North Italy displays higher FNVA and productivity levels. Between 2014 and 2022, the average FNVA increased markedly in North Italy (+17%) but remained almost unchanged in South Italy, widening the regional agricultural income gap. FNVA per AWU showed a similar pattern, with a value of 44,221 euros for North Italy and 29,976 euros for South Italy.

CAP income support is higher in North and Central Italy, although South Italy continues to receive comparatively lower payments (both total and per AWU). Overall, there seems to be a persistent and possibly widening North-South divide in farm structure and performance.

Table 2 reports the results of our regressions with respect to four different dependent variables: FNVA, FNVA per AWU, CAP support and CAP support per AWU, all expressed in euros.

Regarding the validity of models, based on the R squared values, the first two regression models explain 40% and 30% of the variation in FNVA per farm and per AWU, respectively, which can be considered reasonable given the complexity of the phenomenon. On the other hand, the regressions only explain 20% and 10% of the variation in CAP income support per farm and per AWU, respectively. However, given the use of individual-level data, where substantial unexplained heterogeneity is expected, we are confident that the results are valid and informative. The multicollinearity test yields a mean

Table 1. Descriptive statistics of farm characteristics and performance indicators.

	2014				2022			
	North	Centre	South	Total	North	Centre	South	Total
Sample (N.)	4.573	2.005	3.995	10.573	4.844	1.937	4.303	11.084
Sample (%)	*43*	*19*	*38*	*100*	*44*	*17*	*39*	*100*
Type of farming	% over total of macro-region							
Arable crops	*38*	*44*	*30*	*36*	*36*	*44*	*29*	*35*
Permanent crops	*27*	*25*	*35*	*29*	*30*	*28*	*40*	*33*
Livestock	*30*	*23*	*29*	*28*	*28*	*20*	*25*	*25*
Mixed	*6*	*9*	*6*	*6*	*6*	*8*	*6*	*6*
Small	*24*	*25*	*30*	*26*	*16*	*23*	*25*	*21*
Medium	*40*	*42*	*46*	*43*	*44*	*42*	*47*	*45*
Large	*36*	*33*	*25*	*31*	*41*	*34*	*28*	*35*
Variables	Mean (euros)							
Farm net value added	98.305	67.910	63.231	79.289	115.025	75.126	60.574	86.914
Farm net value added/ AWU	36.790	28.736	25.993	31.183	44.221	36.985	29.976	37.426
CAP operating aids	17.817	15.365	12.080	15.184	18.334	20.334	14.478	17.186
CAP operating aids/AWU	8.448	9.150	7.501	8.223	9.137	12.752	9.814	10.032

Note: AWU, annual work unit; CAP, Common Agricultural Policy.
Source: authors' estimations based on the Italian Farm Accountancy Data Network (FADN) dataset for 2014-2022.

Table 2. The results of the ordinary least-squares regressions.

Variables	Y=Farm net Value added	Y=Farm net Value added/ AWU	Y= Cap income support	Y= Cap income support/ AWU
year 2014	base	base	base	base
year 2022	13,974.9***	5,856.4***	450,5	184,3
North * year 2014	base	base	base	base
Centre * year 2014	-6,145.5	-6,678.8***	697,3	334,2
South *year 2014	-7,412.6	-3,730.1***	1,542.6***	1,247.1***
North * year 2022	base	base	base	base
Centre * year 2022	-19,988.9***	-5,940.2***	2,196.6***	2,378.6***
South * year 2022	-24,461.3***	-8,900.0***	845.1**	1,910.8***
Arable crops	base	base	base	base
Permanent crops	5,515.3*	-2,433.6**	-4,222.0***	-4,639.7***
Livestock	-1.574,2	-1.318,3	744.8**	-502.8**
Mixed	-7,768.2**	-4,953.3***	301,1	-1,398.3***
Small	base	base	base	base
Medium	12,816.5***	8,293.3***	3,979.0***	1,926.8***
Large	91,129.2***	25,508.7***	20,966.5***	5,872.9***
CAP support	1.8***	0.4***		
Constant	8,473.2*	19,358.0***	4,616.4***	6,172.6***
Observations	21,226	21,225	21,226	21,225
R-squared	0.4	0.3	0.2	0.1

Notes: Significance levels: *** $p < 0.01$, ** $p < 0.05$, and * $p < 0.1$; AWU, annual work unit; CAP, Common Agricultural Policy.
Source: authors' estimations based on the Italian Farm Accountancy Data Network (FADN) dataset for 2014-2022.

variance inflation factor (VIF) of approximately 1.5 for all regressions, indicating the absence of multicollinearity. This suggests that the predictors are not highly correlated with each other and therefore do not inflate standard errors or compromise the stability of the model estimates.

The intercept term in each regression represents the average expected value for the response variable when all of the predictor variables are equal to zero. In the first regression presented in Table 2, the coefficient of the constant term tells us that, in 2014, the average FNVA of a small farm located in North Italy receiving zero public support, and specialising in the production of arable crops is about 8,500 euros (column two). The transition from 2014 to 2022 has led to an average increase in the FNVA, all other things being equal, of about 14,000 euros per farm, shifting the constant to about 22,500 euros.

Importantly, our variable of interest, given by the interaction between the macro-region variables and the dummy Year, shows how being located in either Central or South Italy reduces the estimated average FNVA for farms, net of public support.

The regression coefficient for the predictor variable represents the difference in the predicted value of the response variable for each one-unit change in that predictor, assuming all other variables remain constant. All else being equal, in 2014, relative to farms in North Italy, the average FNVA was 6,145 euros lower for farms in Central Italy and 7,412 euros lower for farms in South Italy. The difference was even more pronounced in 2022: 19,989 euros for farms in Central Italy and 24,461 euros for farms in South Italy. These substantial differences could be due to varying price dynamics within the same sector across macro-regions, differences in the sectors in which each macro-region is specialised, or other factors.

As shown in column three, the interaction coefficients clearly indicate a widening productivity gap among the macro-regions over time. Overall, FNVA per AWU increased from 2014 to 2022, but it was significantly weaker for farms in South Italy compared with farms in North Italy. The 2022 interaction coefficient for South Italy is strongly negative and substantially larger in magnitude than the corresponding coefficient for 2014, suggesting that the relative disadvantage of farms in South Italy increased during this time period. The result is the same after controlling for farm specialisation, farm size, and CAP income support. The control variables behave as expected: permanent and mixed-crop farms show lower value added compared with arable farms, larger farms exhibit markedly higher productivity levels, and CAP support has a small but positive association with farm performance. Overall, the evidence points to a growing divergence, with farms in South Italy increasingly falling behind despite structural controls.

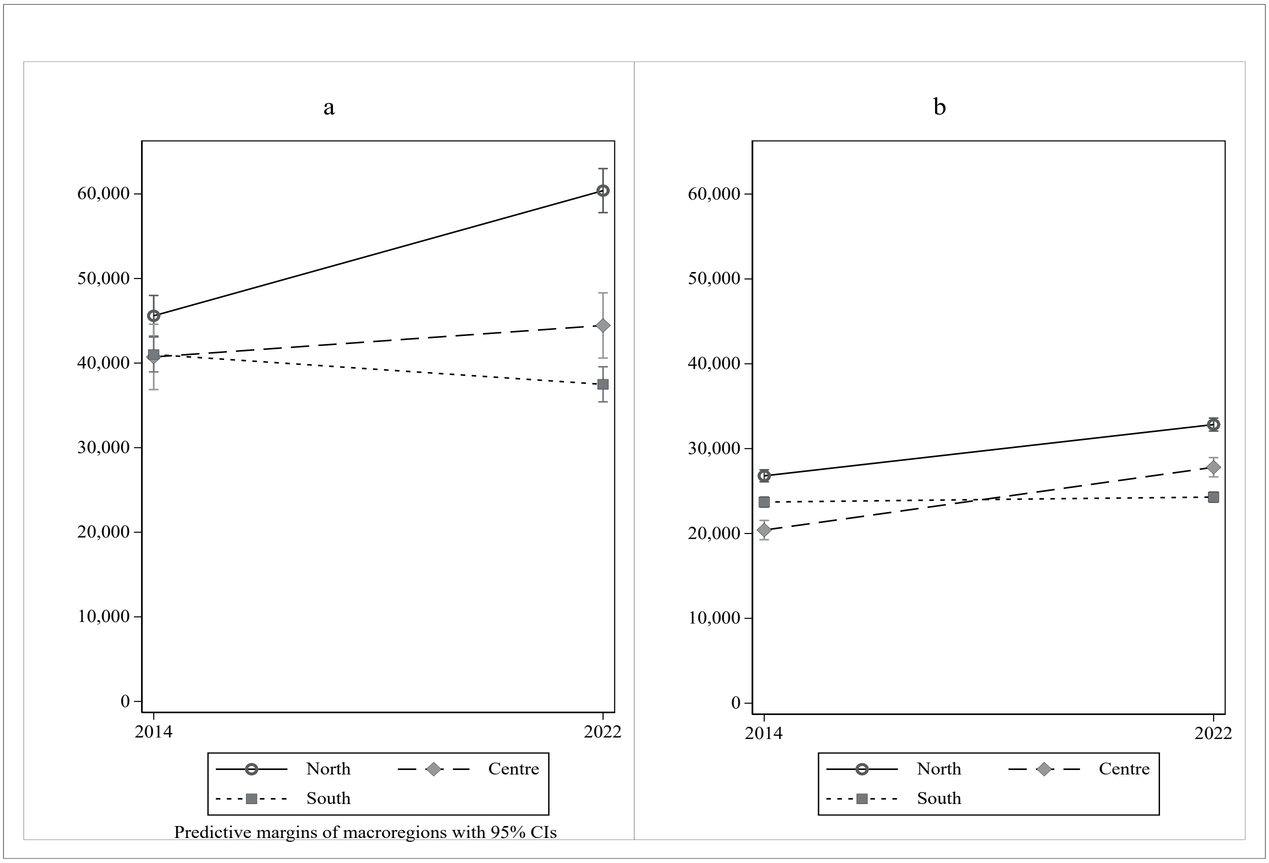
The final two regressions for CAP income per farm and per AWU (columns four and five of the table) show an average increase in support at the farm level from 2014 to 2022. All else being equal, this corresponds to an increase of 450 euros of CAP support per farm and 184 euros of CAP support per AWU. The intercept indicates that in 2014, the "base farm" received 4,616 euros in CAP operating aids per year, which corresponds to 6,173 euros per work unit. In 2022, this support increased to 5,070 euros per farm and 6,357 euros per AWU. We observed positive differences for farms in Central and South Italy compared with farms in North Italy in both 2014 and 2022. Moreover, these differences widened in 2022, when farms in Central and South Italy received relatively more CAP support than their counterparts in North Italy did in 2014.

These two last regressions highlight significant differences in CAP income support across farm types and sizes, all other things being equal. Compared with arable crop farms (the baseline category), permanent crop farms receive substantially lower CAP income support (in total terms and per AWU), with highly significant coefficients of -4,222 and -4,640 euros, respectively. Livestock farms show modestly higher total CAP income support, but significantly less support when expressed per AWU (-502.8 euros), suggesting that support is more diluted across their labour force. Mixed farms do not differ significantly from the baseline in terms of total CAP income support, but support is significantly lower when adjusted per AWU, indicating lower labour productivity or more labour-intensive structures.

Large farms receive significantly higher CAP income support than medium-sized ones, confirming the concentration of CAP payments among larger farms. This pattern persists even when support is expressed per AWU, although the differences are smaller in magnitude, suggesting some scale effects in labour efficiency or payment distribution. It is worth noting that the predominance of small and mixed farms in South Italy influences the ability of this macro-region to intercept CAP support.

Taken together, the interactions between the year and regional dummy variables highlight pronounced geographical disparities in farm performance between 2014 and 2022. Using North Italy as the baseline, Central and South Italy exhibit significantly lower FNVA per farm in 2022. The negative and significant coefficients indicate that farms in these regions have lagged behind those in the North over time, with the South experiencing the largest decline. The patterns are similar for

Figure 7. The average marginal effects of macro-regions on farm net value added (FNVA) (a) and FNVA per annual work unit (AWU) (b) for 2014 and 2022.



Source: authors' estimations based on the Italian FADN dataset for 2014-2022.

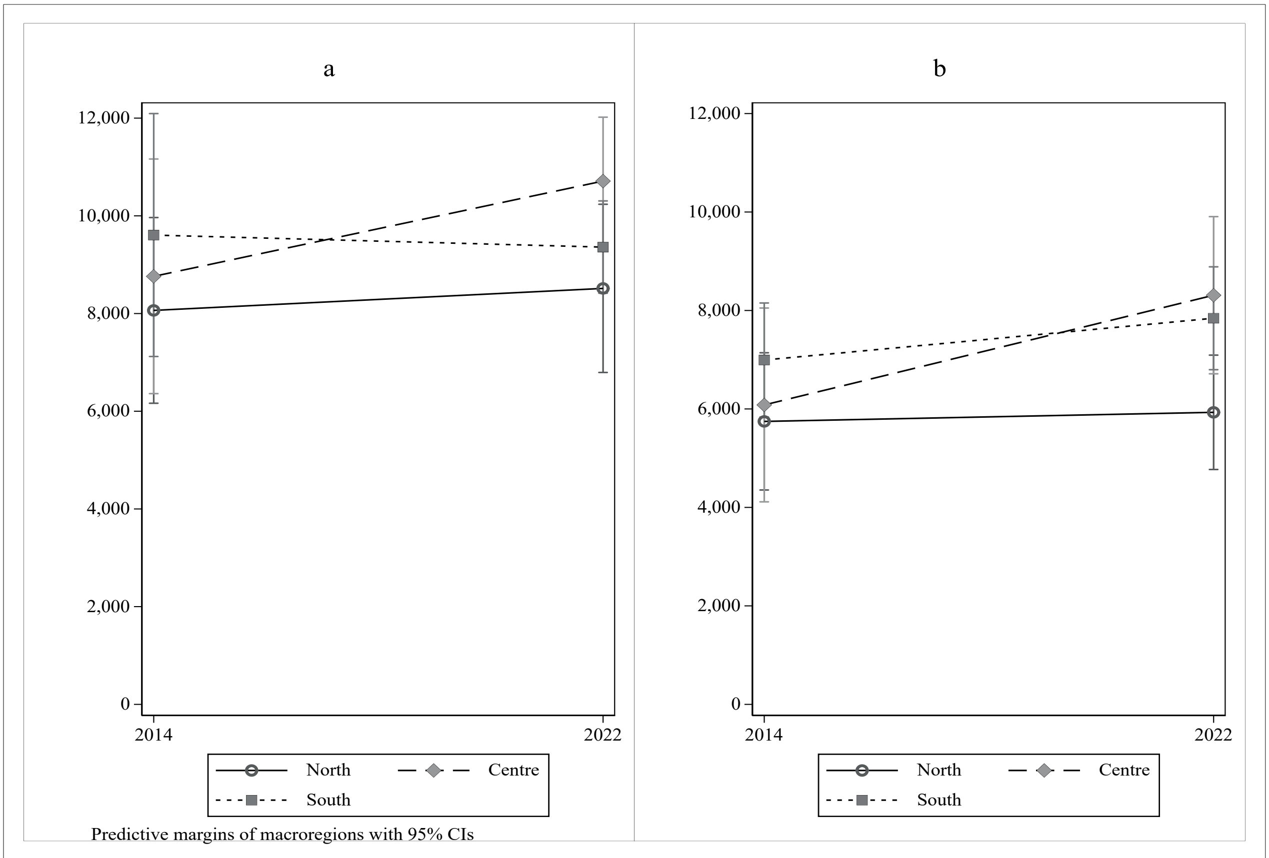
FNVA per AWU, confirming that productivity differentials have widened over time. Interestingly, CAP support does not offset these regional agricultural income gaps: despite South Italy receiving higher CAP income support per AWU in 2022, this increase appears insufficient to bridge the income and productivity divide. Overall, the results suggest a growing North-South polarisation in agricultural economic performance that has only partially been mitigated by policy transfers. These findings suggest that addressing the divide will require structural reforms rather than additional income support alone.

Figures 7 and 8 show the predictive margins in 2014 and 2022 for North, Central, and South macro-regions in Italy, calculated by averaging over all covariates. The graphs display the corresponding difference-in-differences estimates for each macro-region and include confidence intervals, indicating the range of values that, with a given level of confidence, is likely to contain the true population parameter. The margins plots show the model-adjusted predicted means of dependent variables for each macro-region, evaluated at the pre- and post-periods. These margins can be interpreted as the expected values for a "typical" or "average" farm within each group, accounting for the observed distribution of the other covariates and the applied weights. Therefore, the differences between the pre- and post-periods represent the model-based changes in farm performance for an average farm in each macro-region.

Figure 7 reports the margins for FNVA per farm (7a) and per AWU (7b) from 2014 to 2022. The average farm in South Italy widened its gap in value added and labour productivity relative to farms in Central and North Italy.

Figure 8 presents the estimated changes in CAP income support per farm (8a) and per AWU (8b). For each macro-region, there has been an increase in CAP income support over the years (both per farm and per AWU); the North-South differences are positive for South Italy; and the gap remains throughout the period analysed. Despite receiving higher and rising levels of support, farms in South Italy continue to exhibit

Figure 8. The average marginal effects of the macro-regions on Common Agricultural Policy (CAP) income support (a) and CAP income support per annual work unit (AWU) (b) for 2014 and 2022.



Source: authors' estimations based on the Italian FADN dataset for 2014-2022.

substantial, and increasingly large, gaps in agricultural income, both per farm and per AWU.

5. DISCUSSION

As mentioned, few studies have analysed in detail the topic of income gaps in agriculture and the role of the CAP, especially after the introduction of pillars with specific and distinct roles in policy measures in the Agenda 2000 reform. This gap is often taken for granted in the analyses of the effectiveness of CAP support tools, and it has seldom been the central focus. Hence, it is difficult to refer to robust published findings about the role of public support in territorial disparities in agricultural and rural incomes. Nevertheless, we compare our results with some relevant available studies.

In Italy, recent studies have revealed that the aim of the CAP has shifted to reduce agricultural income gaps between central and peripheral areas, and between small and large farms. However, it still fails to address the specific issue of macro-regional agricultural income gaps, perpetuating the "trap" in South Italy. Our work confirms that the "Mezzogiorno problem" and the growing disparity in agricultural income of South Italy compared with the rest of the country still exist, despite the support provided by both regional and agricultural funds.

Following Hansen and Herrmann's (2012) conceptual framework, to fully understand the redistributive impact of a specific policy, the income gap must be analysed at a defined time period and over time (in our case, 2022 vs 2014). At the Italian sub-national level, we found that the agricultural profitability gap between North and South Italy widened over the period 2014-2022. Furthermore, although farms in South Italy receive on average a higher amount of subsidies than farms in North Italy, such support is unable to compensate for the FNVA gap. These results corroborate the negligible effects of the CAP on territorial convergence of agricultural income identified by Esposti

(2007) at the European level and by Hansen and Teuber (2011) in Germany. Analysis at the farm level shows that in 2014, South Italy (and to a greater extent Central Italy) presented a negative gap in agricultural income (FNVA per farm and per AWU) compared with North Italy, and it widened in 2022 compared to 2014. This is due to the combined effect of an increase in agricultural income in North Italy and a reduction in South Italy. At the same time, Central Italy showed an increase in agricultural income, albeit to a lesser extent than North Italy. Farm-level data also confirm that the CAP does not balance territorial disparities in agricultural income. On average, in 2014 farms in South Italy received relatively more CAP income support than farms in North Italy, and this support decreased in 2022. CAP income support per AWU increased between 2014 and 2022 in all three macro-regions, particularly in Central Italy (Figure 8b). In this regard, it should be noted that the first pillar of the CAP, which accounts for the majority of overall farm support, is in fact linked to historical payments granted to specific products, even though the process of internal convergence aims to reduce differences in payments per hectare. This issue can help to explain existing regional disparities in terms of agricultural income.

Another interesting finding from Figure 8 is the higher confidence interval in 2022 compared to 2014. This greater variability can be explained by the entry into force of more complex measures (e.g., investments), which require more time to become fully operational.

6. CONCLUSIONS AND POLICY IMPLICATIONS

This study confirms the existence of gaps in agricultural income across Italy's macro-regions. First, we examined whether the two income components - market income (i.e., FNVA) and CAP support - moved in the same or opposite directions. Subsequently, we used regression models to analyse whether the estimated gaps between macro-regions at the sectoral level persist also accounting for the effects of the different characteristics of the macro-regions' in farming production systems and the role of CAP income support. Our analysis has some limitations. First, we did not fully investigate the contribution of farm specialisation, size, and territorial diversification to the gaps in agricultural income between and within macro-regions. These variables are highly relevant in explaining existing and persisting gaps, given the history of the CAP and the structure of Italian agriculture. Second, we merely established a correlation between agricultural incomes and the investigated variables; it did not allow us to identify any causal relationships. These limits restrict the scope of the paper to some extent; however, the results are still relevant and open the way to further research.

In particular, the sectoral indicators (A, B, and C) revealed a persistent agricultural income gap, with South Italy showing lower agricultural profitability. The regression results confirmed these differences even when farms have the same dimensions and productive characteristics. Indeed, the FNVA gap increased for South Italy during the analysed period. In addition, the analysis of FNVA per AWU demonstrated a negative labour productivity gap for farms in South Italy worsened over time. Conversely, estimates of CAP support differentials show positive gaps for farms in the Centre and South. However, these differentials do not seem to have contributed to reduce or contain gaps in farm income.

Given the current and past picture, what can we expect from the current CAP and the next reform after 2027? Regarding the CAP 2023-2027, the internal convergence of direct payments will continue to shift support from intensive agriculture in lowland areas to extensive agriculture in mountainous areas, marginal areas, and internal peripheral areas, consistent with previous programming. Another shift will result from redistributive income support designed to move financial resources from large farms to small and medium-sized farms. However, these measures have never directly or indirectly addressed the issue of regional disparities, although an effect on the redistribution of support between macro-regions may occur, depending on the structural characteristics of farms located there and their distribution by size. Although small farms benefit from redistributive payments, farms up to 2 hectares and greater than 50 hectares are penalised by the convergence process, to the benefit of farms that are 3-50 hectares in size. More generally, although the Italian CSP has a more tailored and targeted approach, it does not address the issue of sub-national agricultural income disparities in the country, nor does it seem to focus sufficiently on building synergies with other funds operating at the same territorial level.

The reform proposals for the 2028-2034 programming period situate agricultural and rural support within a broader territorial cohesion framework through the creation of the European Fund for Economic, Social and Territorial Cohesion (European Commission, 2025). According to the European Commission, this fund will strengthen the links between policies by providing a unified programming framework for the Cohesion Policy, the CAP, and the Common Fisheries Policy based on a pre-allocated envelope. While this approach is acceptable in some respects, as highlighted in the reviewed literature, it presents certain challenges. Notably, within this framework, the CAP loses its specificity as a sectoral policy, posing a problem of resource governance at the national and regional levels, a very relevant issue in the Italian context. The changes specifically envisaged for the CAP aim at greater convergence of support, definitively eliminating the reference to historical payments and making degressivity and capping of income support per farmer mandatory. Whether this has an impact on the territorial distribution of support will depend on the choices of each MS on how to differentiate support. Our analyses, however, have shown that regions of South Italy already receive relatively more support than the ones in Central and North Italy, but this has not helped to reduce or contain gaps in agricultural income. Instead, structural, organisational, and financial interventions are needed to increase the market component of agricultural income. Only in this way can permanent convergence of agricultural incomes be achieved. Otherwise, the Mezzogiorno trap is likely to persist. The new fund should provide an opportunity to better target support, making policies more consistent with regional needs. Only in this way is it possible to structurally address the factors that determine the persistence of the agricultural income gaps that have emerged.

We addressed the issue of territorial disparities in agricultural income by focusing exclusively on the CAP. This represents an original aspect of the work but can be also seen as a limitation. Future research should focus on integrating this territorial-level analysis of the CAP with Cohesion Policy, overcoming issues of data availability and consistency to provide a coherent understanding of the dynamics at play.

Future research on this field could extend to investigate the factors that contribute to the maintenance of the gap, through the analysis of the causal effects, including other structural and organisational characteristics of farms and variables as proxies for the territorial contexts, such as local prices and externalities, positive and negative. Examining the economic results of the different types of farms will help to identify how much of their results are attributable to the ability to obtain adequate market recognition of their productions and the role played by CAP support. In light of the current CAP and prospects, it is crucial to investigate income components and dynamics, and the importance of the financial support provided by the CAP. Based on our findings, this issue is particularly relevant to balanced and sustainable agricultural and rural area development in Italy.

ACKNOWLEDGEMENTS AND FUNDING

The authors wish to thank Fabrizio De Filippis and the anonymous reviewers for their precious comments and suggestions to the manuscript that contributed to improve the final version of the paper. The responsibility of the contents of the paper is solely of the authors.

AUTHOR CONTRIBUTIONS

Conceptualization, M.R.P.D.A., F.C., A.S. and R.H.; Methodology, F.C. and A.S.; Investigation, M.R.P.D.A., F.C., A.S. and R.H.; Data curation, F.C. and A.S.; Writing - Original Draft, M.R.P.D.A. and R.H.; Writing –Review & Editing, M.R.P.D.A., F.C., A.S. and R.H.; Supervision, M.R.P.D.A., and R.H.

REFERENCES

Alexiadis S., Ladias, C., Hasanagas, N. (2013). A regional perspective of the Common Agricultural Policy. *Land Use Policy*, 30: 665-669. DOI: https://doi.org/10.1016/j.landusepol.2012.05.013.

Accetturo A., Albanese G., Torrini R., Depalo D., Giacomelli S., Messina G., Scoccianti F., Vacca V.P. (2022). *Il divario Nord-Sud: sviluppo economico e intervento pubblico*. Banca d'Italia Workshops and Conferences Series, 25.

Anders S., Harsche J., Herrmann R., Salhofer K., Teuber R. (2007). The interregional and intertemporal allocation of EU producer support: magnitude and determinants. *Jahrbuch für Regionalwissenschaft (Review of Regional Research)*, 27(2): 171-193. DOI: https://doi.org/10.1007/s10037-007-0018-3.

Andrei J.V., Sima V., Gheorghe I.G. (2023). An overview assessing of the European Union agricultural sectorial dynamics: a draft analysis from the Romanian perspective. *Economics of Agriculture*, 70(4): 1235-1250. DOI: https://doi.org/10.59267/ekoPolj23041235V.

Barca F. (2001). New trends and the policy shift in the Italian Mezzogiorno. *Daedalus*, 130(2): 93-113. http://www.jstor.org/stable/20027698.

Bartolini F., Pagliacci F. (2017). Quality of life and territorial imbalances. A focus on Italian inner and rural areas. *Bio-based and Applied Economics*, 6(2): 183-208. DOI: https://doi.org/10.13128/BAE-18518.

Bivand R.S., Brunstad R.J. (2006). Regional growth in Western Europe: detecting spatial misspecification using the R environment. *Papers in Regional Science,* 85(2): 277-297. DOI: https://doi.org/10.1111/j.1435-5957.2006.00086.x.

Bivand R.S., Brunstad R.J. (2003). Regional growth in Western Europe: an empirical exploration of interactions with agriculture and agricultural policy. In Fingleton B. (eds) *European Regional Growth* (pp. 351-373). Springer, Berlin. DOI: https://doi.org/10.1007/978-3-662-07136-6_13.

Bonfiglio A., Camaioni B., Coderoni S., Esposti R., Pagliacci F., Sotte F. (2016). Where does EU money eventually go? The distribution of CAP expenditure across the European space. *Empirica*, 43(4): 693-727. DOI: https://doi.org/10.1007/s10663-016-9354-2.

Calegari E., Fabrizi E., Guastella G., Timpano F. (2021). EU regional convergence in the agricultural sector: Are there synergies between agricultural and regional policies? *Paper in Regional Science*, 100: 23-50. DOI: https://doi.org/10.1111/pirs.12569.

Chmieliński P., Collins A., Cox A., Torrisi G. (2025). Overlapping payoffs and policy synergies: the case of CAP and EU cohesiveness. *Global Challenges & Regional Science*, 2, 100012. DOI: https://doi.org/10.1016/j.gcrs.2025.100012.

Camarero L., Oliva J. (2019). Thinking in rural gap: mobility and social inequalities. *Palgrave Commun* 5(95). DOI: https://doi.org/10.1057/s41599-019-0306-x.

Cirianni A., Fanfani R., Gismondi R., (2021), *Struttura produttiva e performance economica della filiera agroalimentare italiana*, Istat Working Papers, Istat – Istituto Nazionale di Statistica, Rome.

Coppola A., Scardera A., Amato M., Verneau F. (2020). Income levels and farm economic viability in Italian farms: an analysis of FADN data. *Sustainability*, 12(12), 4898. DOI: https://doi.org/10.3390/su12124898.

Crescenzi R., De Filippis F. (2016). Cohesion policy and rural development. In Piattoni S., Polverari L. (eds) *Handbook on Cohesion Policy in the EU* (pp. 325-338). Edward Elgar, Cheltenham. DOI: https://doi.org/10.4337/9781784715670.00036.

Crescenzi R., De Filippis F., Pierangeli F. (2015). In tandem for cohesion? Synergies and conflicts between regional and agricultural policies of the European Union. *Regional Studies*, 49(4): 681-704. DOI: https://doi.org/10.1080/00343404.2014.946401.

Crescenzi R., Giua M. (2014). The EU Cohesion policy in context: regional growth and the influence of agricultural and rural development policies. *LEQS Paper* 85, December. DOI: https://doi.org/10.2139/ssrn.2542244.

Crescenzi R., Giua M. (2016). The EU cohesion policy in context: does a bottom-up approach work in all regions? *Environment and Planning A: Economy and Space*, 48(11): 2340-2357. DOI: https://doi.org/10.1177/0308518X16658291.

Daniele V. (2021). Territorial disparities in labour productivity, wages and prices in Italy: what does the data show?. *European Urban and Regional Studies*, 28: 431449. DOI: https://doi.org/10.1177/09697764211020057.

Dax T. (2006). The territorial dimension of CAP and spatial cohesion. *EuroChoices*, 5(2): 12-19. DOI: https://doi.org/10.1111/j.1746-692X.2006.00029.x.

Dean G.W., De Benedictis M., Fabiani G., Fanfani R., Marenco G. (1972). Potential use of the Mansholt Plan to restructuring agriculture in the Italian Mezzogiorno. *European Economic Review*, 3: 1-28. DOI: https://doi.org/10.1016/0014-2921(72)90021-9.

De Castro P., Miglietta P.P., Vecchio Y. (2020). The Common Agricultural Policy 2021-2027: a new history for European agriculture. *REA – Rivista di Economia Agraria*, 75: 5-12. DOI: https://doi.org/10.13128/rea-12703.

De Filippis F., Henke R. (2014). Modernizzazione e multifunzionalità nell'agricoltura del Mezzogiorno, *QA-Rivista dell'Associazione Rossi-Doria*, 3: 27-58. DOI: https://doi.org/10.3280/QU2014-003002.

Dinis I. (2024). Examining disparities in common agricultural policy direct payments among farming systems: evidence from Portugal. *Agricultural and Food Economics*, 12(7). DOI;: https://doi.org/10.1186/s40100-024-00299-6.

Duhr S., Colomb C., Nadin V. (2010). *European Spatial Planning and Territorial Cooperation*. Routledge, London.

Dumangane M., Freo M., Granato S., Lapatinas A., Mazzarella G. (2021). *The regional dimension of the CAP: 2007-2018*, JRS Technical report, Publications Office of the European Union, Luxembourg. DOI: https://doi.org/10.2760/60203.

Dwyer J., Ward N., Lowe P., Baldock D. (2007). European rural development under the Common Agricultural Policy's 'second pillar': institutional conservatism and innovation. *Regional Studies*, *41*(7): 873-888. DOI: https://doi.org/10.1080/00343400601142795.

Esposti R. (2007). Regional growth and policies in the European Union: does the Common Agricultural policy have a counter-treatment effect? *American Journal of Agricultural Economics*, 89(1): 116-134. DOI: https://doi.org/10.1111/j.1467-8276.2007.00967.x.

European Commission (2001). *Second Report on Economic and Social Cohesion*, Brussels.

European Commission (2021). *Evaluation support study on the impact of the CAP on territorial development of rural areas – Socioeconomic aspects – Final report*, Publications Office of the European Union, Luxembourg. https://data.europa.eu/doi/10.2762/541389.

European Commission (2025). Proposal for a Regulation of the European Parliament and of the Council establishing the European Fund for economic, social and territorial cohesion, agriculture and rural, fisheries and maritime, prosperity and security for the period 2028-2034 and amending Regulation (EU) 2023/955 and Regulation (EU, Euratom) 2024/2509. COM(2025) 565 final/2, Brussels, 16.7.2025.

Eurostat (2018). *Agriculture, forestry and fishery statistics – 2018 edition*, Statistical books, Publications Office of the European Union, Luxembourg. DOI: https://doi.org/10.2785/340432.

Eurostat (2025). *Economic accounts for agriculture - agricultural income indicators*. DOI: https://doi.org/10.2908/AACT_EAA06.

Fabiani G., Henke R. (2020). L'agricoltura meridionale: dall'arretratezza alla dimensione di sistema. In Coco G., De Vincenti C. (eds) *Una questione nazionale. Il Mezzogiorno da "problema" a "opportunità"*. Collana "Quaderni di Astrid" (pp. 237-245). Il Mulino, Milan. DOI: https://doi.org/10.1444/102185.

Frascarelli A., Ciliberti S., Bartolucci P.E., Mastandrea G. (2025). The CAP coherence between redistributive and environmental goals: do the allocation criteria for direct payments play a role? *Agricultural and Food Economics*, 13(15). DOI: https://doi.org/10.1186/s40100-025-00356-8.

Galluzzo N. (2021). The role of CAP subsidies in reducing socio-economic marginalisation in Romanian rural areas. *Bulgarian Journal of Agricultural Science*, 27(4): 633-645.

Giannakis E., Bruggeman A. (2020). Regional disparities in economic resilience in the European Union across the urban–rural divide. *Regional Studies*, 54(9): 1200-1213. DOI: https://doi.org/10.1080/00343404.2019.1698720.

Giannola A. (2009). Dualismo Nord-Sud e Unione Europea: dove va il sistema Italia? *QA- Rivista dell'Associazione Rossi-Doria*, 1: 49-64.

Giarda E., Moroni G. (2018). The degree of poverty persistence and the role of regional disparities in Italy in comparison with France, Spain and the UK. *Social Indicators Research*, 136: 163-202. DOI: https://doi.org/10.1007/s11205-016-1547-3.

Greer A. (2017). Post-exceptional politics in agriculture: an examination of the 2013 CAP reform. *Journal of European Public Policy*, 24(11): 1585-1603. DOI: https://doi.org/10.1080/13501763.2017.1334080.

Guyomard H., Stickel M., Detang-Dessendre C., Soler L.G., Aubert P.M., Carpentier A., Catallo A., Dupraz P., Gaigne C., Regnier E., Thoyer S. (2024). *Research for AGRI Committee—The next reform of the CAP: The variables in the equation*, European Parliament, Policy Department of Directorate for Regional Development, Agriculture and Fisheries Policies, Brussels.

Guyomard H., Detang-Dessendre C., Dupraz P., Delaby L., Huyghe C., Peyraud L., Reboud X., Sirami C. (2023). How the Green Architecture of the 2023–2027 Common Agricultural Policy could have been greener, *Ambio*, 52: 1327-1338. DOI: https://doi.org/10.1007/s13280-023-01861-0.

Hansen H., Herrmann R. (2012). The two dimensions of policy impacts on economic cohesion: concept and illustration for the CAP. *Food Policy*, 37: 483-491. DOI: https://doi.org/10.1016/j.foodpol.2012.02.008.

Hansen H., Teuber R. (2011). Assessing the impacts of EU's Common Agricultural Policy on regional convergence: sub-national evidence from Germany. *Applied Economics*, 43: 3755-3765. DOI: https://doi.org/10.1080/00036841003724395.

Henke R., Benos T., De Filippis F., Giua, M., Pierangeli F., Pupo D'Andrea M.R. (2018). The new common agricultural policy: how do member states respond to flexibility? *JCMS: Journal of Common Market Studies*, 56(2): 403-419. DOI: https://doi.org/10.1111/jcms.12607.

Henke R., Pomponi T., Vassallo M., Mazzocchi G., Monteleone A., Sorrentino A. (2025). The new CAP and the participative method in decision-making: a textual analysis of the Italian case. *JCMS: Journal of Common Market Studies*, 63(6): 1822-1844. DOI: https://doi.org/10.1111/jcms.13703.

Hill B. (2000). Agricultural incomes and the CAP. *Economic Affairs*, 20(2): 11-17. DOI: https://doi.org/10.1111/1468-0270.00217.

Kiss L.B. (2020). Examination of agricultural income inequality in the European Union. *Business Ethics and Leadership*, 4(3): 36-45. DOI: http://doi.org/10.21272/bel.4(3).36-45.2020.

Ilies R.I., Borlea S.N., Lucuţ Capraş I. (202). Theoretical and statistical arguments of the differentiated effect of the Common Agricultural Policy in the EU countries. *Annales Universitatis Apulensis Series Oeconomica*, 25(2): 53-67. DOI: https://doi.org/10.29302/oeconomica.2023.25.2.1.

ISMEA, Svimez (2017). *Rapporto sull'agricoltura del Mezzogiorno. Dicembre 2016*, Rome.

Iuzzolino G., Pellegrini G., Viesti G. (2011). *Convergence among Italian regions, 1861–2011*, Quaderni di Storia Economica (Economic History Working Papers) n. 22, Banca d'Italia, Rome. DOI: https://doi.org/10.2139/ssrn.2239019.

Lepore A. (2012). Il divario Nord-Sud dalle origini a oggi. Evoluzione storica e profili economici. *Rivista Economica del Mezzogiorno*, 3: 389-410. DOI: https://doi.org/10.1432/38969.

Li X., Yang P., Zou Y (2023). An empirical investigation of the "Mezzogiorno trap" in China's agricultural economy: insights from data envelopment analysis (2015–2021). *Agriculture*, 13, 1806. DOI : https://doi.org/10.3390/agriculture13091806.

Lillemets J., Fertő I., Viira A-H. (2022). The socioeconomic impacts of the CAP: systematic literature review. *Land Use Policy*, 114, 105968. DOI: https://doi.org/10.1016/j.landusepol.2021.105968.

Manta A.G., Doran N.M., Bădîrcea R.M., Badareu G., Ghertescu C., Lăpădat C.V.M. (2024). Does Common Agricultural Policy influence regional disparities and environmental sustainability in European Union countries? *Agriculture*, 14(12), 2242. DOI : https://doi.org/10.3390/agriculture14122242.

Mantino F., De Fano G., Asaro G. (2022). Analysing the policy delivery system and effects on territorial disparities in Italy: the mechanisms of territorial targeting in the EU Rural Development Programmes 2014–2020. *Land*, 11, 1883. DOI: https://doi.org/10.3390/land11111883.

Marino M., Rocchi B., Severini S. (2024). Assessing the farm–nonfarm households' income gap along the income distribution in the European Union. *JCMS: Journal of Common Market Studies*, 62(2): 318-340. DOI: https://doi.org/10.1111/jcms.13494.

Martínez García F.M., Cárdenas Alonso G., Nieto Masot A. (2024). Impact of the Common Agricultural Policy (CAP) on the development of rural territories: principal component analysis in SW Spain, Extremadura (2007–2020). *Agriculture*, 14, 1497. DOI: https://doi.org/10.3390/agriculture14091497.

Matthews A. (2024). *What is actually happening with agricultural incomes?*, CAP Reform. http://capreform.eu/what-is-actually-happening-with-agricultural-incomes/.

Meloni C., Grazini C., Marino M., Rocchi B., Severini S. (2024). Are rural households poorer than non-rural households in Europe? *Journal of Rural Studies*, 106, 103214. DOI: https://doi.org/10.1016/j.jrurstud.2024.103214.

Mihai F.C., Iatu C. (2020). Sustainable rural development under Agenda 2030. In Bastante-Ceca M.J., Fuentes-Bargues J.L., Hufnagel L., Mihai F.C., Iatu C. (eds) *Sustainability Assessment at the 21st Century* (pp. 9-18). IntechOpen, London. DOI: https://doi.org/10.5772/intechopen.78105.

Mikuš O., Kukoč M., Jež Rogelj M. (2019). The coherence of common policies of the EU in territorial cohesion: a never-ending discourse? A review. *Agricultural Economics – Czech*, 65: 143-149. DOI: https://doi.org/10.17221/229/2018-AGRICECON.

Mingo R. (2023). The marginality trap. Deconstructing the administrative framework for a reform of local governance: the case of Calabria between top-down and bottom-up dynamics. *Regional Science Policy & Practice*, 15(7): 1458-1476. https://doi.org/10.1111/rsp3.12672.

Molica F., Santos A.M. (2025). Mapping uncharted territory: research gaps in EU cohesion policy from a policy-making perspective. *Regional Studies, Regional Science*, 12(1): 517-531. DOI: https://doi.org/10.1080/21681376.2025.2514503.

Montresor E., Pecci F., Pontarollo N. (2011). The convergence process of the European regions: the role of Regional Policy and the Common Agricultural Policy. *Studies in Agricultural Economics*, 113(2): 167-177. DOI: https://dx.doi.org/10.7896/j.1112.

OECD (2021). *OECD Economic Surveys: European Union 2021*, OECD Publishing, Paris. DOI: https://doi.org/10.1787/a77ab220-en.

Papadopoulos A.G. (2015). The impact of the CAP on Agriculture and Rural Areas of EU Member States. *Agrarian South: Journal of Political Economy*, 4(1): 22-53. DOI: https://doi.org/10.1177/2277976015574054.

Pierangeli F., Biagini L., Pupo D'Andrea M.R., Severini S., Sorrentino A. (2025). The CAP direct payments reform 2023–2027 in Italy: a path to fairer redistribution? *Agricultural and Food Economics*, 13(39): 1-24. DOI: https://doi.org/10.1186/s40100-025-00384-4.

Pierangeli F., Cagliero R., Cesaro L., Carfì S., Giampaolo A., Manzoni P., Pastorelli G., Ruscio L., Scardera A., Pupo D'Andrea M.R. (2023). CAP 2023-2027: effects of direct payments internal convergence in Italy? *Italian Review of Agricultural Economics*, 78(1): 87-96. DOI: https://doi.org/10.36253/rea-14168.

Podbielski G. (1981). The Common Agricultural Policy and the Mezzogiorno. *JCMS: Journal of Common Market Studies*, 19(4): 331-350. DOI: https://doi.org/10.1111/j.1468-5965.1981.tb00240.x.

Quadro Curzio A., Fortis M. (eds) (2014). *L'economia reale nel Mezzogiorno*. Collana della Fondazione Edison. Il Mulino, Milan.

Runowski H. (2020). Dilemmas of measuring and evaluating income in agriculture in the European Union. *Annals of the Polish Association of Agricultural and Agribusiness Economists*, XXII(1): 289-299. DOI: https://doi.org/10.5604/01.3001.0013.7868.

Salvati L., Zitti M., Carlucci M. (2017). In-between regional disparities and spatial heterogeneity: a multivariate analysis of territorial divides in Italy. *Journal* *of Environmental Planning and Management*, 60(6): 997-1015. DOI: https://doi.org/10.1080/09640568.2016.1192023.

Schmid E., Sinabell F., Hofreither M.F. (2006). *Distributional effects of CAP instruments on farm household incomes in Austria*. 2006 American Agricultural Economics Association Annual Meeting, July 23-26, Long Beach, CA. DOI: https://doi.org/10.22004/ag.econ.21467.

Shucksmith M., Cameron S., Merridew T., Pichler F. (2009). Urban–rural differences in quality of life across the European Union. *Regional Studies*, *43*(10): 1275-1289. DOI: https://doi.org/10.1080/00343400802378750.

Shucksmith M., Thomson K.J., Roberts D. (eds) (2005). *The CAP and the Regions: The Territorial Impact of the Common Agricultural Policy*. CABI Publishing, Wallingford, UK.

Tarditi S., Zanias G. (2001). *Common agricultural policy*. In Hall R., Smith A., Tsoukalis L. (eds) Competitiveness and Cohesion in EU Policies (pp. 179-215). Oxford University Press, Oxford. DOI: https://doi.org/10.1093/oso/9780198295228.003.0006.

Uthes S., Herrera B. (2019). *Farm-level input intensity, efficiency and sustainability: a case study based on FADN farms. 59th Annual Conference*, Braunschweig, Germany, September 25-27, 2019, German Association of Agricultural Economists (GEWISOLA). DOI: https://doi.org/10.22004/ag.econ.292342.

Watson M.M. (1970). *Regional Development Policy and Administration in Italy*. Longman Group Ltd., London.

APPENDIX

Table A.1. List of the Common Agricultural Policy (CAP) measures included in the Italian Farm Accountancy Data Network (FADN) used in this study.

	Aid granted on an operating account basis
Pillar I payments	Sectoral support under Common Market Organisation (Regulation (EU) 1234/2007, 479/2008, and 1308/2013)
	Specific support (Regulation (EU) 73/2009, article 68)
	Optional implementation for specific types of farming and quality production (Regulation (EU) 1782/2003, article 69)
	Voluntary coupled support (Regulation (EU) 1307/2013, article 52)
	Single payment scheme (Regulation (EU) 1782/2003)
	Basic income support (Regulation (EU) 1307/2013)
	Payment for agricultural practices beneficial for the climate and the environment (Regulation (EU) 1307/2013)
	Small farmers scheme (Regulation (EU) 1307/2013)
	Payment for young farmers (Regulation (EU) 1307/2013)
Pillar II payments	Italian Rural Development Plan 2007-2013 (Regulation (EU) 1698/2005)
	Axis I – Competitiveness
	Knowledge and human potential (article 20(a) – M. 111, 112, 114, and 115)
	Physical potential and innovation (article 20(b) – M. 124)
	Quality of agricultural production and products (article 20(c) – M. 131, 132, 133, and 144)
	Axis II – Environment and countryside
	Sustainable use of agricultural land (article 36(a) – M. 211, 212, 213, 214, 215, and 216)
	Sustainable use of forestry land (article 36(b) – M. 221, 222, 223, 224, 225, 226, and 227)
	Axis III – Quality of life in rural areas and diversification
	Training and information (article 52(c) – M. 331)
	Axis IV – LEADER
	Competitivity (article 63(a) – M. 411)
	Running the local action group, acquiring skills and animating the territory (article 63(c) – M. 431)
	Italian Rural Development Plan 2014-2020 Regulation (EU) 1305/2013
	Knowledge transfer and information actions (article 14 – M. 1.1)
	Advisory services, farm management, and farm relief services (article 15 – M. 2.1, 2.2, and 2.3)
	Quality schemes (article 16 – M. 3.1 and 3.2)
	Non-productive investments linked to the achievement of agri-environment-climate objectives (article 17 – M. 4.4)
	Restoring agricultural production potential (article 18 – M. 5.1 and 5.2)
	Farm and business development (article 19 – M. 6.1, 6.2, and 6.3)
	Basic services and village renewal in rural areas (article 20 – M. 7.2 and 7.8)
	Investments in forest area development (article 21 – M. 8.1, 8.2, 8.3, and 8.6)
	Agri-environment-climate payments (article 28 – M. 10.1 and 10.2)
	Organic farming (article 29 – M. 11.1 and 11.2)
	Natura 2000 and Water Framework Directive payments (article 30 – M. 12.1, 12.2, and 12.3)
	Payments to areas facing natural or other specific constraints (article 31 – M. 13.1, 13.2, and 13.3)
	Animal welfare (article 33 – M. 14)
	Forest-environmental and climate services and forest conservation (article 34 – M. 15.1 and 15.2)
	Co-operation (article 35 –M. 16.1 to 16.7 and 16.9)
	Risk management (article 36 – M.17.1, 17.2, and 17.3)
	LEADER local action groups (article 42 – M. 19.1 to 19.4)

Table A.2. Absolute values of Indicators A, B, C, and D (values in euros).

	2014	2015	2016	2017	2018	2019	2020	2021	2022
Indicator A: Index of the real income of factors in agriculture per annual work unit									
North	35,999	37,117	36,324	37,284	37,995	34,535	40,395	45,994	45,648
Centre	24,319	26,033	24,508	24,349	25,573	25,677	29,330	29,609	33,173
South	22,240	23,022	22,720	22,674	22,155	22,820	24,579	26,586	25,361
Total	27,517	28,796	28,333	28,495	28,826	27,902	31,292	34,279	34,316
Indicator B: Index of real net agricultural entrepreneurial income, per unpaid annual work unit									
North	28,932	31,021	30,479	32,390	33,587	29,364	36,857	44,904	42,989
Centre	20,524	22,922	20,528	20,301	21,216	21,354	25,975	25,549	30,480
South	22,429	22,773	22,021	21,745	20,447	20,666	24,482	26,577	23,416
Total	24,799	26,198	25,436	25,946	26,122	24,463	29,783	33,825	32,514
Indicator C: Net entrepreneurial income of agriculture									
North	34,051	37,267	36,938	38,279	40,055	34,834	47,428	57,041	55,224
Centre	23,630	26,692	22,481	22,624	23,646	23,603	28,892	28,856	33,457
South	20,166	20,686	18,725	19,315	17,624	17,594	21,555	23,484	20,752
Total	25,656	27,503	25,816	26,614	26,553	24,649	31,299	35,502	34,171
Indicator D: Net entrepreneurial income of agriculture, net of CAP support, in Italian FADN									
North	24,777	27,006	27,489	29,084	30,986	25,200	35,556	45,494	43,795
Centre	15,093	17,501	14,356	14,281	14,229	14,271	19,436	17,637	21,670
South	12,540	12,679	11,968	12,168	10,508	10,056	13,777	15,294	12,384
Total	17,308	18,519	17,897	18,561	18,410	16,105	21,902	25,737	24,270

Note: CAP, Common Agricultural Policy; FADN, Farm Accountancy Data Network.
Source: authors' elaborations based on the Italian FADN dataset for 2014-2022.

REA | ITALIAN REVIEW OF AGRICULTURAL ECONOMICS

Firenze University Press
www.fupress.com/rea

OPEN ACCESS

Citation: Mantino, F., De Fano, G., & Asaro, G. (2025). Reaching the margins: Addressing demographic transition through EU Cohesion and Rural Development Policies in Italy. *Italian Review of Agricultural Economics* 80(3): 43-59. DOI: 10.36253/rea-16853

Received: November 4, 2025

Revised: November 27, 2025

Accepted: December 4, 2025

Data Availability Statement: Data will be made available by the corresponding author upon request.

Competing Interests: The Author(s) declare(s) no conflict of interest.

Guest Editor: Marcello De Rosa

ORCID
FM: 0000-0001-5338-4333
GDF: 0000-0003-1893-4795
GA: 0009-0009-3317-4449

Research article

Reaching the margins: Addressing demographic transition through EU Cohesion and Rural Development Policies in Italy

Francesco Mantino[1,*], Giovanna De Fano[2], Gianluca Asaro[3]

[1] *CREA – Research Centre for Agricultural Policies and Bioeconomy, Italy*
[2] *National Research Council, Italy*
[3] *AEIDL, Belgium*
*Corresponding author. E-mail: francesco.mantino@crea.gov.it; francomantino5@gmail.com

Abstract. The impact of demographic decline on the allocation of policy instruments and public funding across territories has received limited attention. This study therefore identifies the key variables that influence the uptake of EU policies to clarify the conditions that may hinder the participation of declining territories in public programmes. This research is the first to jointly consider EU cohesion policy – through the European Regional Development Fund (ERDF) and the European Social Fund (ESF) – and rural development policy, financed by the European Agricultural Fund for Rural Development (EAFRD). A territorial typology of municipalities was adopted based on the EUROSTAT degree of urbanisation (DEGURBA) classification of urban–rural boundaries, combined with long-term demographic trends. This typology makes it possible to capture the differences between urban and rural areas, as well as the heterogeneity within each group. We examined the influence of territorial typology and other explanatory variables on per capita spending under ERDF, ESF and EAFRD using spatial autoregressive models. The results reveal that demographic decline significantly undermines the capacity of rural areas to attract EU policies, as it progressively erodes the institutional strength of local authorities and the entrepreneurial ability of private actors to undertake investments and safeguard territorial capital over time.

Keywords: demographic change, rural areas, cohesion policy, rural development policy, spatial econometric models, impact territorial assessment.
JEL codes: R58, O18, Q18, J11.

HIGHLIGHTS

- ERDF and ESF are predominantly allocated to urban areas, whereas EAFRD spending is mainly directed to rural municipalities.
- Rural areas demonstrate a higher capacity to absorb EAFRD per capita funding compared to ERDF across all demographic categories.
- In light of the 2028–2034 EU policy reform, the risk emerges that rural priorities – especially in demographically and economically fragile areas

– may be underrepresented or deprioritised in the allocation of resources within the integrated national plans.

1. INTRODUCTION

Demographic change has emerged as one of the key transitions currently facing the European Union (EU). Over the long term – since 1960 – the population of Europe has steadily increased, with the sole exception of the temporary decline during the COVID-19 pandemic. The total population rose from 354.5 million in 1960 to 450.4 million as of January 2025, an increase of 95.9 million. This growth, particularly evident in the last decade, has been driven primarily by a positive net migration rate, which has offset the negative natural population change.

In 2024, only six EU Member States – Sweden, Ireland, Luxembourg, France, Cyprus and Malta – recorded a positive natural population change, while positive net migration was observed across all EU countries. EUROSTAT (2021) has developed a classification of European countries (including European Free Trade Association-EFTA and candidate countries) based on the drivers of demographic change, distinguishing between population growth and decline, as well as the relative contribution of natural change and net migration. Two subgroups can be identified among countries experiencing population growth: one in which growth is driven by both positive net migration and natural increase (11 countries), and another in which net migration is the sole driver, with natural increase remaining negative (13 countries). Conversely, countries experiencing population decline – such as Italy – are characterised by insufficient net migration to offset the high negative natural change rate.

Depopulation is shaped by a combination of structural factors (OECD, 2025). First, fertility rates have consistently fallen below the replacement threshold. Across the EU-27, the average fertility rate declined from 1.54 children per woman in 2012 to 1.38 in 2023, with all Member States falling below the replacement level of 2.1. The lowest rates are observed in Italy, Spain, Poland, Latvia and Malta. This decline is attributable primarily to long-standing socio-economic and cultural dynamics. As noted by the OECD,

> In a vicious cycle, places suffering from out-migration of youth will experience accelerated rates of ageing, high age dependency ratios and a declining share of population in reproduction age, leading to falling birth rates. These factors make it less attractive for the youth population and thus fuel further emigration of youth, lower birth rates, and more population decline (OECD, 2025).

Population ageing, driven by increasing life expectancy, is the second major factor contributing to depopulation. While longer life spans represent one of the most significant demographic achievements of the 21st century, they also pose substantial challenges. The sustainability of this demographic shift depends on the strength of younger generations. A sharp decline in the youth population leads to imbalances in the ratio of the elderly to working age populations – a ratio that underpins economic productivity and the viability of social services. In the EU-27, the old-age dependency ratio rose markedly from 27.7 in 2012 to 33.9 in 2024, with Italy recording the highest value at 38.4.

Demographic change exhibits strong territorial dimensions, affecting regions and rural areas in differentiated ways (OECD, 2025). In the Italian context, regional disparities have widened between the Centre-North and the Mezzogiorno. Southern Italy is undergoing a more pronounced population decline and demographic imbalance, with an accelerated ageing process over recent decades. Once among the most prolific areas in Western Europe during the early post-war period, the Mezzogiorno reached fertility and demographic levels comparable to the national average by the early 21st century.

Birth rates and the presence of young people of working and reproductive age in the South have benefited less from foreign immigration, which has been more concentrated in central and northern regions. Internal migration towards the Centre-North has also intensified since the mid-1990s: between 1995 and 2008, approximately 1.7 million people – almost exclusively Italian citizens – moved from Southern Italy to the Centre-North (Rosina and Impicciatore, 2022). This trend has exacerbated territorial disparities, as increasingly dynamic and highly educated young individuals leave the South, thus contributing to the depletion of human capital and accelerating both population decline and ageing. This spiral results in a dual outflow – quantitative and qualitative – that undermines the region's capacity to reactivate development processes.

These dynamics become even more evident when examining intra-regional differences between urban areas, peri-urban zones, rural areas near urban centres and remote rural territories. Proximity to urban centres remains a key factor in analyses of demographic and socio-economic trends. The OECD classification is one of the most widely cited approaches to defining rural areas through an urban–rural relational lens; this classification considers the relationship between rural and urban centres and proximity to urban hubs as determinants of economic performance and development potential. Based on an indicator of closeness to urban centres, the OECD typology (Brezzi *et al.*, 2011) identifies five categories: (a) urban or predominantly urban regions; (b) intermediate regions close to an urban centre; (c) remote intermediate regions; (d) predominantly rural regions close to an urban centre; and (e) remote predominantly rural regions. This classification has been applied in official OECD reports and numerous academic studies, typically at the NUTS3 level.

However, demographic phenomena have a territorial granularity that requires analysis below the NUTS3 level. Using data at the local administrative unit (LAU) level allows for a more accurate exploration of demographic change, while avoiding the high heterogeneity associated with NUTS3-level analysis. More recently, Perpiña Castillo *et al.* (2024) have employed a set of indicators at the municipal level to explore the diversity among cities, towns and villages; rural areas close to cities; and remote rural areas. In Italy, further granularity is provided by the concept of "inner peripheries" as defined by the National Inner Areas Strategy (NIAS), which identifies remote areas based on their distance from essential service providers (e.g. primary and secondary schools, railway stations, healthcare facilities). The NIAS is a multi-fund policy specifically designed to counteract depopulation in areas with limited access to services. It classifies municipalities into four categories: (a) metropolitan poles; (b) inter-municipal poles; (c) peri-urban areas; and (d) inner areas, which include intermediate, peripheral and ultra-peripheral zones.

The migratory flow originating from inner areas and directed towards central areas (metropolitan zones, inter-municipal hubs and peri-urban areas) has been significant over the past 20 years. Nearly half of these departures (46.2%) come from inner areas in Southern Italy, 34.1% from those in the North and 19.7% from inner areas in Central Italy (ISTAT, 2024). Conversely, urban centres in the North receive most of these migrants (50.8%), followed by those in the South (25.9%) and Central Italy (23.3%). About half of the migrations from southern inner areas are directed towards central areas within the same southern region, while one-third head to central areas in the North, thus confirming the persistence of traditional south-to-north migration flows.

Foreign migration rates have been positive and, at least until 2012, have helped to offset internal migration outflows from these areas. After that date, however, foreign migration also stabilised at lower levels, which has resulted in a negative overall migration rate. After 2020, due to the COVID-19 pandemic and the subsequent return of residents, the net migration balance in inner areas became positive once again.

Over the past 20 years, the number of young Italian graduates who have moved from inner areas to central areas or abroad has steadily increased, while return flows have remained limited. According to ISTAT (2024), between 2020 and 2023, inner areas lost 132,000 young graduates to central areas and 28,000 to foreign countries. Overall, this represents a negative balance of 160,000 young graduates for the inner areas. The gap between inner areas and central areas has thus widened significantly over time, driven by a more pronounced decline in the youth population in inner areas. This decline is driven by both falling birth rates and the emigration of younger cohorts, which has been particularly intense in these territories.

In addition to the demographic effects, numerous studies have examined the socio-economic and environmental impacts of depopulation. Drawing on recent research (OECD, 2025; EC, 2020, 2023; Mantino *et al.*, 2024), several types of impacts can be identified. The first relates to the labour market, productivity and long-term growth, as population decline leads to a shrinking labour force, reduced market dynamism and lower propensity for innovation. The second is a reduction in the fiscal base, as depopulation diminishes the tax base and revenues from public service fees. The third encompasses effects on service and infrastructure delivery, as ageing and depopulation increase per-capita operating costs and shift service demand – reducing needs for education and public transport while increasing the demand for healthcare and elderly infrastructure. The fourth is governance and project development capacity, as the depletion of human resources in local governments undermines institutional capacity and the ability to design and implement development projects. The fifth impact is on civil society, because youth outmigration and shrinking public services weaken social cohesion and community vitality, thus fostering a sense of abandonment and growing distrust in institutions. The final impact is on the environment, as demographic shifts are closely linked to changes in land use. Land abandonment, a significant consequence of rural depopulation, is common in areas with steep terrain, low agricultural productivity or poor infrastructure. According to FAO (2020), abandonment patterns vary across Europe but often correlate with marginality and accessibility. The environmental outcomes are mixed: in some cases, abandonment increases risks such as wildfires, erosion and invasive species; in others, it promotes rewilding and carbon sequestration, ultimately enhancing biodiversity and ecosystem services.

Despite the growing relevance of demographic decline in the debates on territorial development, limited attention has been paid to its implications for the allocation and uptake of public policies and funding instruments across different types of territories. The present study addresses this gap by exploring which variables influence the use of EU policies and identifying the conditions that hinder the participation of specific areas – particularly those affected by demographic shrinkage – in public policy frameworks. While previous research has primarily focused on rural development policies (see Section 2), the novelty of this study lies in its integrated analysis of both cohesion policy instruments, namely the European Regional Development Fund (ERDF) and the European Social Fund (ESF), as well as rural development policy under the European Agricultural Fund for Rural Development (EAFRD). In doing so, the study examines the core components of the European Structural and Investment Funds (ESIF), the overarching objective of which is to reduce internal disparities in socio-economic and structural conditions among regions and territories, including rural–urban divides. The following questions guided the research:

a) What differences can be observed among the EAFRD, ERDF and ESF in explaining policy uptake in rural areas with varying demographic characteristics?
b) To what extent do demographic change and other territorial factors influence policy uptake, and what differences emerge among rural regions when analysed at a finer spatial scale?
c) Based on the findings for the previous questions, to what degree are EU structural policies contributing to the promotion of territorial cohesion?

2. LITERATURE REVIEW

Participation in policy schemes – commonly referred to as the *policy uptake rate* – has been the subject of numerous studies in the academic literature, particularly during the second decade of the 2000s. These analyses have primarily focused on Rural Development Programme (RDP) measures, especially agri-environmental schemes (Bartolini *et al*., 2012; Defrancesco *et al*., 2008; Marconi *et al*., 2015; Pascucci *et al*., 2013; Yang *et al*., 2014) and, in some cases, structural interventions such as those under Axis 1 (Pascucci *et al*., 2013) and Axis 3 (Zasada and Piorr, 2015).

Econometric models have been employed to investigate the influence of various factors on policy uptake, which is treated as the dependent variable. In these models, policy uptake has been operationalized using three distinct types of indicators:

a) the percentage of farms benefiting from the policy scheme relative to the total number of farms in the region;
b) a binary variable, equal to 1 for recipient farms and 0 for non-recipient farms, typically used in logit regression models (Pascucci *et al*., 2013; Defrancesco *et al*., 2008); and
c) the amount of payments delivered per inhabitant or per hectare of utilised agricultural area (Marconi *et al*., 2015; Yang *et al*., 2014; Zasada and Piorr, 2015).

Indicator (c) is particularly suitable when the policy schemes target the broader rural population rather than a specific beneficiary category, such as farmers. It also facilitates comparative analysis across different types of EU funds. Indicator (b) is predominantly applied in studies of agri-environmental schemes, where comparisons between recipient and non-recipient farms are conducted using panel data. Indicators (a) and (c) are generally used when spatial data are available at the municipal level.

Demographic variables are included as explanatory factors in nearly all models. These are represented both by general population characteristics – such as population density, age group distribution and net migration rate – and by specific attributes of farmers, including age and the presence of a successor. Territorial typologies are also incorporated among the explanatory variables, in various forms, to capture differences in natural resource endowments and labour market conditions.

Several definitions of rural areas have been considered, including less-favoured areas, high nature-value areas and broader conceptualisations of territorial diversity, such as the urban/rural or accessibility/remoteness dichotomies (Öir *et al*., 2020; Yang *et al*., 2014, 2015). However, these variables often fail to yield statistically significant results in regression analyses.

Agricultural typologies have been examined from multiple perspectives, including farm structure, farm type, the share of agriculture in the local economy and agricultural productivity. For example, Pascucci *et al.* (2013) distinguish between internal factors – related to farm and farmer characteristics – and external factors, which include indicators of participation in professional and social networks. Zasada and Piorr (2015), in their analysis of participation and expenditure under Axis 3 measures, identify three categories of explanatory variables: farming community, landscape and rural community. The latter includes demographic and labour market indicators. Their study demonstrates that Axis 3 measures in the Brandenburg region – such as tourism development and village renewal – primarily target rural areas characterised by structural weaknesses and vulnerability to demographic transition. A synoptic overview of these models is presented in Mantino *et al.* (2024).

In these models, limited attention has been paid to factors related to the efficiency of policy delivery mechanisms. To better understand the role of these specific dimensions, it is necessary to explore the literature on cohesion policy evaluation. The concept of *quality of government* has been extensively developed by Charron *et al.* (2014), who propose a set of indicators suitable for its measurement. This concept has been operationalised to assess the impact of cohesion policy programmes on regional economic outcomes, such as per capita income growth and economic convergence (Rodríguez-Pose and Garcilazo, 2013), as well as technological progress (Rodríguez-Pose and Di Cataldo, 2014); in both studies, the authors highlight a strong relationship among the quality of regional institutions, the capacity to absorb development funds and economic growth. However, operationalising the concept of government quality remains challenging, as it requires decomposing the notion of government into distinct components[1].

Moreover, the indicators commonly used in expenditure models at the European level suffer from significant limitations due to their high level of aggregation. These indicators often fail to capture substantial differences in spending efficiency across funds, programmes and categories of investment projects (European Parliament, 2019). Such limitations underscore the need for more disaggregated indicators explicitly linked to the administrative capacities of the managing authorities responsible for implementing EU funds and programmes.

3. MATERIALS AND METHODS

3.1. Defining a typology of demographic change

As previously discussed, demographic indicators have been widely used in EU-level research to investigate territorial disparities across European regions. A common analytical approach involves developing territorial classifications of rural areas experiencing population shrinkage (Copus *et al.*, 2020) and using demographic profiling based on long-term population trends (Colantoni *et al.*, 2020). These typologies are typically constructed by intersecting two key dimensions:

Table 1. Typology of long-term demographic change.

Number of decades between 1991 and 2021 and related trend	Annual rate of population change between 1991 and 2021			
	≤ −0.6	−0.59/0	0/+0.49	≥ +0.50
Growth over three decades			Resilient	Vital
Mixed growth and decline	Mixed		Mixed	
Decline over three decades	Very fragile	Fragile		

Source: Authors' own elaboration.

a) the temporal extent of population growth or decline, assessed over three or more decades to capture long-term patterns; and
b) the magnitude of demographic change, measured through average population variation across the entire observation period and categorised into defined classes.

Advanced studies benefit from access to highly disaggregated population data, ideally at the LAU level, which enables more precise spatial analysis. Building on these dimensions, a new classification of demographic change was developed using municipal-level data (see Table 1). The timeframe from 1991 to 2021 was segmented into three decades (1991–2001, 2001–2011 and 2011–2021), and three categories of temporal change were identified:

- Persistent population growth across all three decades.
- Mixed growth and decline over the decades, and
- Persistent population decline across all three decades.

Four classes of average annual population change were then defined, distinguishing between rates of increase and decrease above or below the national medians for the period 1991–2021 (−0.59% for decline and +0.49% for growth). By intersecting the duration and magnitude of change (both positive and negative), five categories of long-term demographic change were identified (see Table 1).

These categories can be further distinguished according to the EUROSTAT classification of the degree of urbanisation (DEGURBA). According to this classification, individual municipalities can be grouped into two main categories: urban areas, including cities and towns and semi-dense areas, and rural areas[2]. The typol-

[1] According to Charon et al. (2010, p.9), these components include the rule of low, corruption, quality of bureaucracy or bureaucratic effectiveness, democracy and strength of electoral institutions.

[2] The classification process involves two main stages. Stage 1 classifies 1 km² grid cells based on population density and size into categories such as urban centres (high density and population), urban clusters (moderate density and population, excluding urban centres), and rural grid cells. Stage 2 then classifies small spatial units (like municipalities) into final categories: cities (majority population in an urban centre), towns

ogy of demographic change is therefore disaggregated into five urban and five rural categories, yielding a total of 10 municipal types (see the population breakdown in Table 3).

3.2. The econometric model, variables and data used

As highlighted in the literature review, various econometric approaches have been employed to investigate the determinants of policy uptake across territories. A key distinction emerges between aspatial models, which do not account for geographic relationships, and spatial econometric models, which explicitly incorporate spatial dependencies (LeSage, 1997). The latter have gained prominence in regional economics and policy evaluation, particularly for addressing issues of spatial autocorrelation – that is, the tendency for observations of the dependent variable or residuals to exhibit systematic spatial patterns. Anselin (2002) demonstrated that in the presence of spatial dependence, estimates derived from ordinary least squares regressions may be biased and inconsistent. To address this, two main types of spatial models are commonly used:

a) Spatial lag models, which include a spatially lagged dependent variable among the regressors. This formulation captures the idea that policy uptake in a given municipality may be influenced by uptake in neighbouring areas, reflecting potential spillover effects.
b) Spatial error models, which assume that spatial dependence is present in the error terms. This suggests that omitted variables shared across neighbouring units may be influencing the outcome, leading to correlated residuals.

Several studies have incorporated both forms of spatial dependence into their modelling frameworks (e.g. Bartolini *et al*., 2012; Marconi *et al*., 2015; Yang *et al*., 2014), demonstrating the added explanatory power of spatial econometric techniques in territorial policy analysis. In terms of model specification, spatial autoregressive (SAR) models can be viewed as extensions of standard linear regression models that formally incorporate spatial relationships into the equation. This allows for a more accurate representation of territorial dynamics and interdependencies:

$$r = \rho\,(W1\ r) + X\,\beta + \varepsilon \qquad (1)$$

$$\varepsilon = \lambda\,(W2\ \varepsilon) + \mu \qquad (2)$$

where r is the observed participation rate, $W1$ and $W2$ are $n \times n$ standardised matrices of spatial weights applied, respectively, to the lag-dependent variable r and errors, X is the $n \times n$ matrix of k explanatory variables, ε is the error term, ρ is the spatial lag parameter, λ is the spatial error coefficient and β is the regression parameter. When $\rho = 0$ and $\lambda = 0$ in Equations (1) and (2), Equation (1) becomes a standard linear regression model; when $\rho = 0$, Equation (1) becomes a spatial error model; and finally, when $\lambda = 0$, Equation (1) becomes a spatial lag model.

In this study, the dependent variables representing policy uptake for each fund are defined as the committed expenditures per inhabitant at the municipal level, disaggregated by the ERDF, ESF and EAFRD schemes. The list of dependent variables used in the regression models is presented in Table 2, which also summarises the specific schemes included in the analysis for each dependent variable. Regression analyses were conducted separately for each fund and for homogeneous categories of investment support, with a particular focus on the distinction between measures aimed at sectoral competitiveness and those targeting territorial capital. This distinction is especially relevant for ERDF and EAFRD, as it allows for an exploration of whether significant differences in policy uptake emerge depending on the type of support provided. Understanding these differences is crucial for assessing the alignment between policy instruments and the demographic and territorial characteristics of the recipient areas.

Regarding the EAFRD, only investment schemes have been considered in this study, as the focus is on RDP support for investments in both the agricultural sector and the broader rural context during the 2014–2020 programming period. This choice ensures comparability with ERDF and ESF investment typologies. However, data on public and private expenditures by measure and sub-measure are not systematically available at either the national or regional level. This information gap necessitated an intensive and time-consuming effort to collect data from publicly available lists of approved and funded projects published by each region following the issuance of public calls. This data collection process enabled the compilation of detailed information on committed expenditures for approved projects, disaggregated by investment scheme type and municipality. It also included data on beneficiaries' residences and the time elapsed between the call opening date and project approval. In total, data were gathered from 1,352 calls across regional RDPs, representing the complete set of investment measures selected by regional administrations.

and semi-dense areas (intermediate category), and rural areas (majority population in rural grid cells).

Table 2. List of dependent variables used in regressions.

Variable name	Variable description	Support schemes included
ERDFpercapita	Committed expenditures by ERDF projects per inhabitant (Eur per capita)	All categories of measures envisaged by ERDF operational programmes
ESFpercapita	Committed expenditures by ESF projects per inhabitant (Eur per capita)	All categories of measures envisaged by ESF operational programmes
EARDFpercapita	Committed expenditures by EAFRD projects per inhabitant (Eur per capita)	M4 (farm and non-farm investments); M6 (start-up aids and non-agricultural activities); M7 (basic services and rural infrastructures); M8 (forest investments); M16 (Cooperation); M19 (LEADER)
ERDFcompetitiveness	Committed expenditures by ERDF projects for competitiveness per inhabitant (Eur per capita)	ERDF measures for industrial competitiveness, digital networks, research and development, transports and mobility
ERDFterritory	Committed expenditures by ERDF projects for service and infrastructures per inhabitant (Eur per capita)	ERDF measures for population services, inclusion and healthcare, culture and tourism, environment and energy
EAFRDcompetitiveness	Committed expenditures by EAFRD projects for competitiveness per inhabitant (Eur per capita)	EARFRD measures for farm investments, agri-food industry, young farmers, innovation in agriculture (M4.1; M4.2; M6.1; M6.2; M16)
EAFRDterritory	Committed expenditures by EAFRD projects for broader rural territory per inhabitant (Eur per capita)	EAFRD measures for rural infrastructures, non-productive investments, non-agricultural activities, basic services and local action group investments (M4.3; M4.4; M6.4; all M7; LEADER)

Source: Authors' own elaboration.

For ERDF and ESF, data collection was facilitated by the availability of project-level datasets from OPENCOESIONE, which provides open and accessible data on the planning, implementation and financing of projects funded by European and national cohesion policy instruments during the 2014–2020 period. These include ESIF, the National Development and Cohesion Fund (Fondo per lo Sviluppo e la Coesione – FSC), and the Cohesion Action Plan (Piano d'Azione per la Coesione – PAC). The dataset includes information on committed and paid expenditures, beneficiary location and project implementation procedures.

The main limitations of the dataset used in this analysis concern the localisation of beneficiaries. First, not all ERDF and ESF projects are implemented within a single municipality; many have a broader territorial scope involving multiple municipalities. In such cases, there is no reliable criterion to allocate expenditures across the concerned municipalities, and these projects were excluded from the analysis. This exclusion led to the consideration of €16,224 million in ERDF and €7,144 million in ESF expenditures, representing 52% and 39%, respectively, of the total committed spending on Italy for the 2014–2020 period. For EAFRD, the data collection covered €3,484 million, corresponding to 55% of the committed spending on the same period.

By following the regression model described in equations (3) and (4), per capita expenditures of single Fund are dependent on a series of variables as in the following equations:

$$\log Ypc_i = \rho\ (W1 \log Ypc_i) + \beta\ Dem_i + \gamma\ \Sigma X_i + \varepsilon \qquad (3)$$

$$\varepsilon = \lambda\ (W2\ \varepsilon) + \mu \qquad (4)$$

where $logYpc_i$ is the logarithm of the per capita expenditure in the i-th municipality, Dem_i is the demographic typology and ΣX_i is the set of variables included in the model. The list of explanatory variables is described in the Appendix.

The STATA programme was used to create the spatial weighting matrix *W*. We applied the same matrix *W* to the lag-dependent variable and errors (W1 = W2). *W* is a symmetrical matrix 7900 × 7900 (the number of Italian municipalities) and a contiguity matrix with the same positive weight for contiguous spatial municipalities and, by default, a zero weight for all other units. Municipal contiguity was taken into account in accordance with the communal code. *W* is also a spectral normalised matrix created by dividing the entries by the absolute value of the largest eigenvalue in the matrix (StataCorp, 2023). In practice, spectral normalisation produces estimates of ρ and λ in the range of −1 to +1 (with 0 meaning no spatial effects). To fit the model with endogenous regressors for cross-sectional data (as in the case of the independent variable), we used a generalised method of moments estimator known as generalised spatial two-stage least squares (GS2SLS) and STATA software version 18, which allows the estimation of all the regressor parameters jointly after creating the W matrix.

A complete list of explanatory variables is provided in the Appendix. Among the explanatory variables, how administrative efficiency was calculated requires clarification. In this study, we focused on the time elapsed between the call opening date and each project's approval date, expressed as the number of days per €1,000 of committed expenditure. This phase is considered crucial for assessing administrative performance. However, approval times may not solely reflect administrative efficiency, as they can also be influenced by factors such as project size (a proxy for investment complexity) and the number of applications received (representing the administration's workload).

To estimate the portion of approval time attributable to administrative efficiency, we employed the following regression model:

$$\text{Approval Time}_{ij} = \beta_0 + \beta_1 \bullet \text{ProjSize}_{ij} + \beta_2 \bullet \text{No.Applications}_i\, j + \varepsilon_{ij} \quad (5)$$

where the approval time for the *i*-th municipality and *j*-th fund is modelled as a function of project size and the number of submitted applications. The residual term ε_{ij} captures unexplained variation and is interpreted as the component of approval time potentially attributable to administrative efficiency. Specifically, the error term is the efficiency score, reflecting the difference between the actual approval time and the expected time based on observable factors. A negative residual indicates that the administration was faster than expected (i.e. an efficiency gain), while a positive residual suggests slower-than-expected performance (i.e. an efficiency loss). This approach allows us to derive an efficiency score for each municipality and fund, controlling for project complexity and administrative workload.

4. RESULTS

This section first describes the characteristics of the typology adopted, which is based on demographic variables and the degree of urbanisation. It then presents the results obtained from the SAR econometric model.

4.1. Typologies of demographic change in Italy

Between 1991 and 2011, the Italian population increased by approximately 2.7 million, reaching 59.9 million in 2011. In the following decade (2011–2021), the population declined by just over 400,000 inhabitants (Table 3). This decrease affected rural areas almost exclusively, with a loss of around 584,000 inhabitants, partially offset by growth of approximately 150,000 in urban areas. The demographic weight of rural municipalities has steadily declined, dropping from 18.3% in 1991 to 17% in 2021. This loss has occurred primarily in the most vulnerable rural areas (classified as fragile and very fragile clusters), notably in mountainous and hilly regions. The classification also highlights the presence of weak urban-type municipalities, mainly located in hills and plains. Overall, the most demographically fragile municipalities – both rural and non-rural – accounted for just over 17% of the total population in 2021. If a portion of the "mixed rural and urban" category is also considered, this share could potentially reach up to one quarter of the Italian population.

The main difference is that fragile rural municipalities are predominantly small or very small (Table 4). In contrast, fragile urban municipalities tend to be medium-sized and, in many cases, provincial or regional capitals. This pattern reflects an ongoing process of de-urbanisation affecting some medium- to large Italian cities. In recent decades, demographic fragility has become increasingly concentrated in Southern Italy, both in urban and – more markedly – in rural municipalities. Approximately 70% of the population residing in fragile urban municipalities is located in southern regions, and a similar proportion is found in very fragile rural municipalities in Southern Italy.

To address the research questions, it is first necessary to explore the actual distribution of funds (ERDF, ESF and EAFRD) across different types of municipalities (Table 5). In addition, within the EAFRD, we distinguished LEADER commitments from other RDP measures. Table 5 shows that ERDF and ESF are predominantly allocated to urban areas, whereas EAFRD expenditures are mainly directed to primary rural municipalities, and LEADER interventions more clearly target rural municipalities than any other fund.

Based on the demographic classification, the ERDF appears to address the needs of the most disadvantaged areas, with approximately one quarter of its resources allocated to fragile and very fragile urban municipalities. On the rural side, the needs of fragile and very fragile municipalities are primarily addressed by the EAFRD

Table 3. Evolution of the Italian population 1991–2021 by demographic type.

Demographic typology	Population share 1991 (%)	Population share 2011 (%)	Population share 2021 (%)	Population change 1991–2011 (thousands inhabitants)	Population change 2011–2021 (thousands inhabitants)	Total area 2021 % Distribution by altitude zones			
						Mountain	Hill	Plain	Italy
URBANmunicipalities	*81.7*	*82.2*	*83.1*	2,474.8	151.7	*14.8*	*43.3*	*68.9*	*39.2*
Vital urban	*14.1*	*17.4*	*18.4*	2,349.9	536.6	*2.2*	*8.0*	*15.7*	*7.7*
Resilient urban	*4.3*	*4.4*	*4.6*	218.1	55.7	*0.5*	*2.8*	*5.3*	*2.6*
Mixed urban	*48.5*	*47.6*	*47.8*	733.1	-72.7	*9.3*	*23.9*	*36.9*	*21.8*
Fragile urban	*9.9*	*8.8*	*8.5*	-390.7	-222.2	*1.4*	*5.2*	*7.2*	*4.3*
Very fragile urban	*4.9*	*4.0*	*3.7*	-435.6	-145.6	*1.3*	*3.4*	*3.7*	*2.7*
RURAL municipalities	*18.3*	*17.8*	*16.9*	190.0	-583.9	*85.2*	*56.7*	*31.1*	*60.8*
Vital rural	*2.1*	*2.6*	*2.7*	379.2	74.7	*6.2*	*3.8*	*5.0*	*4.9*
Resilient rural	*0.5*	*0.5*	*0.5*	23.8	5.5	*2.9*	*0.5*	*0.9*	*1.4*
Mixed rural	*8.6*	*8.8*	*8.4*	389.9	-270.9	*28.9*	*25.4*	*17.0*	*24.7*
Fragile rural	*1.9*	*1.7*	*1.6*	-58.3	-73.4	*7.4*	*6.2*	*2.8*	*5.9*
Very fragile rural	*5.3*	*4.2*	*3.6*	-544.5	-319.8	*39.7*	*20.8*	*5.4*	*23.9*
Italy (1,000 inhabitants)	57.440	59.904	59.472	2.665	-432	7.193	23.251	29.027	59.472
Italy (%)	*100.0*	*100.0*	*100.0*	*4.6*	*-0.7*	*100.0*	*100.0*	*100.0*	*100.0*

Source: Authors' elaboration of Italian population census 1991, 2001, 2011 and 2021, Central Statistics Institute (ISTAT).

Table 4. Distribution of Italian population classes of municipal size and demographic type.

Demographic typology	% Classes of municipal size and administrative role							% Total population 2021	% Population Share 2021 in South Italy
	less than 2000	2,000–5,000	5,001–20,000	20,001–50,000	Over 50,000	Provincial head city	Regional head city		
URBAN municipalities	*0.7*	*4.2*	*31.2*	*20.8*	*7.1*	*17.0*	*19.0*	*100.0*	*33.6*
Vital urban	*0.6*	*6.5*	*54.9*	*24.6*	*7.5*	*5.9*	*0.0*	*100.0*	*20.7*
Resilient urban	*0.3*	*2.4*	*36.2*	*40.2*	*4.9*	*11.7*	*4.4*	*100.0*	*22.4*
Mixed urban	*0.8*	*3.8*	*23.6*	*20.0*	*7.6*	*21.9*	*22.3*	*100.0*	*31.6*
Fragile urban	*0.4*	*2.3*	*23.8*	*11.9*	*4.5*	*17.9*	*39.2*	*100.0*	*70.4*
Very fragile urban	*0.9*	*3.0*	*23.0*	*8.9*	*8.3*	*12.6*	*43.2*	*100.0*	*53.3*
RURAL municipalities	*29.9*	*43.8*	*25.0*	*1.2*	*0.0*	*0.1*	*0.0*	*100.0*	*33.1*
Vital rural	*13.5*	*38.8*	*44.5*	*3.3*	*0.0*	*0.0*	*0.0*	*100.0*	*14.1*
Resilient rural	*18.4*	*41.9*	*39.7*	*0.0*	*0.0*	*0.0*	*0.0*	*100.0*	*22.9*
Mixed rural	*27.1*	*45.0*	*26.8*	*0.8*	*0.0*	*0.3*	*0.0*	*100.0*	*21.6*
Fragile rural	*28.8*	*49.1*	*20.0*	*2.1*	*0.0*	*0.0*	*0.0*	*100.0*	*46.7*
Very fragile rural	*50.7*	*42.9*	*6.5*	*0.0*	*0.0*	*0.0*	*0.0*	*100.0*	*69.4*
Italy	*5.6*	*10.9*	*30.2*	*17.5*	*5.9*	*14.1*	*15.8*	*100.0*	*33.5*

Source: Authors' elaboration of Italian population census 2021, Central Statistics Institute (ISTAT).

and particularly by the LEADER approach. However, it is essential to note that the financial resources available through EAFRD, especially LEADER, are significantly lower than those of the ERDF and ESF (Table 5).

4.2. The results of SAR econometric models

As previously discussed, multiple factors influence the uptake of EU funds. Table 6 presents the results of the SAR models estimating the uptake of the three main funds. The table also reports the estimated coefficients

Table 5. Distribution of European Structural and Investment Funds by demographic type in Italy in 2014–2020.

Demographic typology	% Population 2021	% ERDF	% ESF	% EAFRD	% EAFRD-LEADER
Urban municipalities	*83.1*	*85.0*	*94.1*	*42.0*	*27.8*
Vital urban	*18.4*	*8.5*	*8.7*	*11.2*	*4.9*
Resilient urban	*4.6*	*3.0*	*3.6*	*3.2*	*0.9*
Mixed urban	*47.8*	*49.2*	*62.6*	*23.1*	*14.2*
Fragile urban	*8.5*	*19.7*	*13.1*	*2.6*	*5.3*
Very fragile urban	*3.7*	*4.5*	*6.0*	*1.8*	*2.5*
Rural Municipalities	*16.9*	*15.0*	*5.9*	*58.0*	*72.2*
Vital rural	*2.7*	*1.3*	*0.8*	*5.7*	*4.2*
Resilient rural	*0.5*	*0.6*	*0.8*	*1.3*	*0.8*
Mixed rural	*8.4*	*6.0*	*2.4*	*29.1*	*30.7*
Fragile rural	*1.6*	*1.4*	*0.5*	*5.4*	*8.1*
Very fragile rural	*3.6*	*5.7*	*1.4*	*16.6*	*28.5*
Total	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*
Total (million Eur)		16.224	7.143	3.279	0.205

Source: Authors' elaboration of data from OPENCOESIONE (ERDF and ESF) and lists of projects approved by Regions (EAFRD).

in logarithmic form, which indicate the marginal effect of each explanatory variable on policy uptake, along with their standard errors. To streamline the econometric analysis, specific municipal categories have been aggregated. Following the classification adopted in previous studies (e.g., Copus *et al*., 2020), the "fragile" and "very fragile" categories have been grouped under the widely used label "shrinking urban/rural", while the "vital" and "resilient" categories are grouped as "growing urban/rural".

The pseudo-R^2 values are relatively good for per capita ERDF and EAFRD expenditures, while they are lower for ESF per capita spending. Both the rural–urban typology and demographic dynamics significantly influence fund absorption rates. Specifically, the various rural categories (growing, shrinking and mixed) exhibit a significant and positive association with the uptake of ERDF and EAFRD. In contrast, the coefficients for ESF are either statistically insignificant or negative (particularly for shrinking rural areas), reflecting the ESF's predominant focus on urban contexts (Table 6).

Rural areas demonstrate a higher capacity to absorb EAFRD per capita funding compared to ERDF across all demographic categories, as evidenced by the significantly larger estimated coefficients. This outcome can be attributed to the targeted nature of Italian RDP measures, which are specifically designed to support agricultural and rural beneficiaries – an approach not mirrored in the ERDF and ESF operational pro-

Table 6. Regressions outcomes of SAR models on the three EU funds.

Independent variables	Dependent variable		
	Lg_ERDF-percapita	Lg_ESFper-capita	Lg_EAFRD-percapita
Constant	9.495***	-1352	24.45***
	(-1371)	(-1500)	(-1447)
Demographic typology			
- Growing urban	-0.0661	0.0539	-0.0666
	(0.0614)	(0.0645)	(0.0599)
- Shrinking urban	0.0682	-0.153	-0.0494
	(0.0910)	(0.101)	(0.0823)
- Growing rural	0.392***	-0.0307	0.787***
	(0.0837)	(0.0924)	(0.0680)
- Mixed rural	0.527***	-0.0781	0.877***
	(0.0571)	(0.0632)	(0.0491)
- Shrinking rural	0.794***	-0.188**	0.966***
	(0.0693)	(0.0790)	(0.0577)
Territorial disparities			
Capital_cities	0.734***	1.028***	-1.000***
	(0.134)	(0.140)	(0.116)
Lg_oldagerate	0.442***	1.350***	0.429***
	(0.0952)	(0.107)	(0.0782)
Lg_migrationrate	-0.233	-0.0829	-0.0953
	(0.172)	(0.205)	(0.117)
Lg_jobseekers	0.397***	0.337***	-0.312***
	(0.0548)	(0.0616)	(0.0450)
Lg_accessibility	-1.801***	0.214	-7.508***
	(0.384)	(0.405)	(0.476)
Lg_Broadband speed	-0.0787**	0.0368	-0.172***
	(0.0313)	(0.0351)	(0.0232)
Agricultural area			
Lg_shareagricarea	0.00405	-0.0915***	0.0602***
	(0.0236)	(0.0268)	(0.0197)
Lg_productivityha	-0.178***	0.0368	0.0310
	(0.0221)	(0.0246)	(0.0199)
Funds' efficiency			
Lg_Administrative efficiency	-0.611***	-0.639***	-0.839***
	(0.0128)	(0.0138)	(0.0175)
Spatial parameters			
Lg_ERDFpercapita	0.0952***	0.294***	0.0447***
	(0.0180)	(0.0298)	(0.0148)
e.Lg_ERDFpercapita	0.704***	0.879***	0.998***
	(0.0345)	(0.0402)	(0.0287)
Statistics			
Observations	4,957	4,040	4,796
Pseudo R^2	0.4094	0.3290	0.4747
Wald chi^2	2974.22	2863.17	4437.82
Prob > chi^2	0.0000	0.0000	0.0000

*** $p < .01$, ** $p < .05$, * $p < .1$.
Source: authors' elaborations from their own database and STATA processing procedures.

grammes. Notably, shrinking rural areas exhibit the highest per capita expenditure coefficients, a result reflecting the substantial allocation of rural development funds to agricultural regions in southern Italy, as well as the more favourable EU co-financing rates available to both agricultural and non-agricultural actors in lagging rural areas (Mantino *et al.*, 2022).

Being a provincial or regional capital emerges as a significant positive determinant of ERDF and ESF per capita expenditure, as indicated by the positive coefficients. In contrast, this variable is negatively associated with EAFRD spending, which suggests that such municipalities tend to be excluded from rural development funding. This pattern reflects the strategic orientation of ERDF and ESF, which tend to prioritise investments in infrastructure and socio-economic development within metropolitan and medium-sized urban areas (see also Münch *et al.*, 2024). Conversely, fund absorption appears to be negatively correlated with accessibility and broadband service, implying a priority of EU resources in regions facing greater challenges in accessing essential services – particularly in the Mezzogiorno. As expected, EAFRD per capita expenditure increases with the share of agricultural employment, while the relationship is negative for both ERDF and ESF, consistent with their broader development objectives. Furthermore, ERDF and ESF allocations are positively associated with municipalities characterised by higher shares of unemployed individuals and elderly populations, thus indicating a targeted response to socio-economic vulnerability.

Administrative efficiency also plays a critical role across all three funds. The negative sign of the coefficient suggests that shorter administrative processing times for project selection and approval are associated with higher per capita spending. Given the logarithmic specification of the model, the coefficients can be interpreted as elasticities: a 10% reduction in administrative delays is associated with an average increase in per capita spending of approximately 6% to 8%. This effect is particularly pronounced in the case of EAFRD, where disparities in administrative capacity among regional authorities are more substantial compared to those observed for ERDF and ESF.

The parameters ρ and λ, which respectively indicate the spatial dependence of the lagged dependent variable and the spatial correlation of the error terms, are positive and statistically significant across all estimated equations. This result confirms the presence of spatial effects and supports the adoption of a SAR model.

Significant differences emerge when analysing investment categories within EU funds, particularly between competitiveness-oriented and territorial interventions (Table 7). In the case of ERDF competitiveness investments, the capacity to absorb higher levels of funding is more pronounced in capital cities than in rural municipalities, which reflects both stronger demand and greater investment capacity in urban contexts. This is further supported by the negative correlation with migration rates, which suggests that areas experiencing population decline are less able to mobilise competitiveness-related resources. In contrast, EAFRD competitiveness spending shows a positive association with shrinking rural areas, confirming the prioritisation of these territories within rural development strategies. Nonetheless, the coefficient linked to agricultural productivity indicates that competitiveness support is increasingly concentrated in areas with higher agricultural performance, suggesting a more effective use of EU funds in regions characterised by intensive farming systems.

Territorial investments under both ERDF and EAFRD are positively correlated with indicators of socio-economic disadvantage. Municipalities associated with higher per capita spending typically exhibit demographic decline, limited accessibility and digital connectivity, elevated ageing indices, and lower productivity levels. Notably, only ERDF territorial investments maintain a positive correlation with capital city status.

The pursuit of more efficient project assessment and approval processes continues to demonstrate its relevance in enhancing policy uptake across all investment categories. The impact is particularly evident in EAFRD competitiveness expenditures, where substantial regional disparities in administrative efficiency – especially between the north and the south – translate into significant differences in fund absorption. These gaps highlight the potential for targeted improvements in administrative capacity to optimise the effectiveness of EU funding in lagging regions.

5. DISCUSSION

Demographic change has emerged as one of the most pressing structural challenges in recent decades and is expected to remain a central transition for European countries in the coming years. In the Italian context, this transition manifests along two distinct territorial dimensions: (a) a north–south divide that reflects the more pronounced demographic decline observed in southern regions over the past decade; and (b) an urban–rural dimension, characterised by population shrinkage in many rural areas, particularly in peripheral and mountainous territories. These demographic dynamics impose significant constraints on economic

Table 7. Regressions outcomes of SAR models on investment categories within ERDF and EAFRD.

Independent variables	Dependent variable			
	Lg_ERDFCompetitiveness	Lg_EAFRDcompetitiveness	Lg_ERDFterritorypc	Lg_EAFRDterritorypc
Constant	7.173***	23.26***	11.25***	25.66***
	(-1483)	(-1858)	(-1762)	-1.886
Demographic typology				
- Growing urban	-0.00835	-0.201***	-0.508***	-0.0755
	(0.0629)	(0.0716)	(0.0948)	(0.0944)
- Shrinking urban	0.0617	0.0226	0.0946	0.0193
	(0.0943)	(0.108)	(0.122)	(0.115)
-Growing rural	0.258***	0.651***	0.460***	0.739***
	(0.0885)	(0.0821)	(0.125)	(0.104)
- Mixed rural	0.414***	0.774***	0.812***	1.104***
	(0.0603)	(0.0612)	(0.0832)	(0.0725)
- Shrinking rural	0.501***	0.965***	1.216***	1.232***
	(0.0756)	(0.0739)	(0.0954)	(0.0813)
Territorial disparities				
Capital_cities	0.742***	-1.062***	0.569***	-1.798***
	(0.136)	(0.134)	(0.150)	(0.156)
Lg_oldagerate	0.358***	0.128	0.419***	0.682***
	(0.103)	(0.0996)	(0.138)	(0.110)
Lg_migrationrate	-0.364*	-0.0283	-0.504**	-0.432**
	(0.203)	(0.153)	(0.248)	(0.177)
Lg_jobseekers	0.0289	-0.235***	0.119	-0.186***
	(0.0591)	(0.0579)	(0.0779)	(0.0602)
Lg_accessibility	-0.691*	-7.404***	-1.529***	-6.820***
	(0.397)	(0.621)	(0.449)	(0.599)
Lg _Broadband speed	-0.0571*	-0.222***	-0.104**	-0.189***
	(0.0345)	(0.0301)	(0.0438)	(0.0336)
Agricultural area				
Lg_shareagricarea	-0.0467*	0.119***	-0.0673*	-0.0972***
	(0.0252)	(0.0265)	(0.0367)	(0.0271)
Lg_productivityha	-0.141***	0.151***	-0.197***	-0.243***
	(0.0234)	(0.0253)	(0.0335)	(0.0276)
Funds' efficiency				
Lg_Administrative efficiency	-0.608***	-0.810***	-0.447***	-0.589***
	(0.0136)	(0.0227)	(0.0205)	(0.0272)
Spatial parameters				
Lg_ERDFpercapita	0.117***	0.0781***	0.0472*	0.106***
	(0.0226)	(0.0201)	(0.0274)	(0.0217)
e.Lg_ERDFpercapita	0.629***	0.986***	0.898***	0.849***
	(0.0414)	(0.0368)	(0.0433)	(0.0515)
Statistics				
Observations	4,275	3,526	2,770	3,036
Pseudo R^2	0.3544	0.4403	0.3463	0.4911
Wald chi^2	2271.00	2667.70	1113.17	2492.43
Prob > chi^2	0.0000	0.0000	0.0000	0.0000

*** $p < .01$, ** $p < .05$, * $p < .1$.
Source: authors' elaborations from their own database and STATA processing procedures.

development across the country, arising from the interplay between global transformations and localised socio-economic processes. This study adopted a territorial typology of municipalities based on the DEGURBA classification of urban–rural boundaries, combined with long-term demographic trends, which enabled a more nuanced analysis of territorial disparities, capturing not only the differences between urban and rural areas but also the heterogeneity within each category.

Using this framework, we analysed the distribution of EU funds across different municipal categories and estimated, through SAR models, the influence of territorial typology and other explanatory variables on per capita spending under the ERDF, ESF and EAFRD. The results reveal substantial differences among the three funds in terms of their territorial allocation. The ESF predominantly targets urban municipalities, while the EAFRD is more strongly oriented towards rural areas, particularly those experiencing demographic decline. The ERDF occupies an intermediate position: although it prioritises urban areas, it also allocates a non-negligible share of resources to declining municipalities, especially within the urban category.

In addition to confirming the descriptive findings, the econometric estimates provide a more nuanced understanding of the role of demographic characteristics within a multivariate framework. The use of SAR models is particularly appropriate in this context, as it mitigates the risk of biased and inconsistent coefficient estimates due to spatial autocorrelation. A comparative analysis of the econometric results across the three funds reveals that demographic decline does not constitute a barrier to EAFRD fund allocation. This outcome reflects the fund's explicit territorial targeting, which prioritises rural areas over urban and peri-urban areas. This pattern is especially evident in investments addressing broader territorial needs – such as support for non-agricultural activities and services for the rural population – while it is less pronounced in competitiveness-related investments, which tend to favour agriculturally productive areas with greater absorption capacity. In contrast, the ESF appears to follow an opposing logic, assigning lower priority to rural and demographically declining areas and concentrating its resources in urban contexts. The ERDF similarly favours urban municipalities, with declining rural areas exhibiting limited capacity to access funding, particularly for competitiveness-related interventions. However, in the case of territorial investments – such as infrastructure and service provision – there is a positive correlation between fund absorption and rural demographic decline, suggesting that these municipalities are better able to mobilise resources for such purposes.

Although the EAFRD is formally part of the Common Agricultural Policy (CAP), it is also recognised as a core component of the ESIF, alongside the ERDF, ESF, Cohesion Fund and European Maritime and Fisheries Fund. The Treaty of Lisbon (Article 174) underscores the objective of territorial cohesion, encompassing not only lagging regions but also rural areas and territories facing severe and permanent natural or demographic disadvantages, such as sparsely populated northern regions, islands, cross-border regions and mountainous areas. In this context, the findings of this study indicate that both the ERDF and EAFRD contribute to the overarching goal of reducing disparities in access to essential services and digital infrastructure. This is evidenced by the statistical significance and direction of the estimated coefficients across the three funds. However, more specific territorial disparities – whether between urban and rural areas or among municipalities with divergent demographic trajectories – are more consistently addressed by the EAFRD than by the ERDF. As for the ESF, both the expenditure analysis and regression results suggest a limited capacity to account for territorial disparities, likely due to the fund's predominant focus on labour market vulnerabilities rather than spatial inequalities. These conclusions are consistent with previous research (e.g. Crescenzi and Giua, 2016; Kline and Moretti, 2014), which highlighted the limited effectiveness of regional policies in the most disadvantaged areas, often attributable to weaker planning and advocacy capacities. This appears particularly evident in rural and demographically declining areas, where intra-regional disparities are most pronounced.

Demographic decline significantly undermines the capacity of rural areas to attract EU policies, as it progressively erodes the institutional strength of local authorities and the entrepreneurial ability of private actors to undertake investments and safeguard territorial capital over time. This progressive loss of capacity encompasses both public and private investments, generating a self-reinforcing vicious cycle in which each dimension adversely affects the other. The erosion of capacity is particularly acute in relation to competitiveness-oriented investments rather than territorial ones, given that private investments appear to be more sensitive to demographic contraction than public expenditure. Furthermore, the contraction in investment demand within rural areas is markedly more pronounced for ERDF and ESF resources than for EAFRD, owing to two main factors: (a) the structural difficulty for rural areas to compete with urban territories; and (b) the explicit targeting of rural areas by the EAFRD, in contrast to the broader scope of the ERDF and ESF.

Administrative efficiency emerges as a critical determinant in explaining regional disparities in the absorption of EU funds. This study highlights the need to move beyond generalized assessments of institutional quality at the regional level, advocating instead for a more granular analysis that considers the specific characteristics of each fund and the nature of the investments it supports. The findings suggest that institutional quality is not uniformly distributed within regions, challenging the common assumption of regional homogeneity in administrative capacity. This insight should be considered when designing interpretative models of EU policy impacts and when implementing administrative reforms to improve fund management and delivery.

Several methodological limitations should be acknowledged when interpreting the results of this study. First, the data collection process excluded projects with multi-municipal or supra-local scopes, particularly those with a multi-localisation code and broader territorial coverage. This limitation primarily affected urban areas, given the concentration of large-scale projects in metropolitan contexts. Second, the econometric analysis did not account for potential interactions among different EU funds and programmes. Previous studies (e.g. Crescenzi and Giua, 2016) have emphasised the importance of such complementarities, particularly between cohesion policy and the CAP. Finally, the analysis did not disaggregate results by macro-regional clusters (e.g. Northern, Central and Southern Italy), which could provide further insights into territorial heterogeneity and may represent a valuable direction for future research.

6. CONCLUSIONS AND POLICY IMPLICATIONS

Definitions of rurality at the European level have recently been standardised through the DEGURBA classification, which provides a harmonised framework for distinguishing urban and rural areas. Building on this framework, the present study integrated the concept of long-term demographic dynamics to refine the territorial typology employed in the analysis. By combining multiple data sources at the LAU level, this study identified a set of significant variables that influence the uptake of EU policies.

The conclusions outlined in the preceding section form the basis for a series of policy considerations, particularly in light of the European Commission's (EC's) recent proposals in July 2025 for the Multiannual Financial Framework (MFF) 2028–2034 and the associated reform of the EU policy architecture (EC, 2025a). These reflections aim to contribute to the ongoing debate on how to better align EU funding instruments with the evolving territorial and demographic challenges faced by Member States.

Among the key proposals outlined in the EC's Communication on the future Multiannual Financial Framework (MFF) 2028–2034 is the establishment of a single integrated fund which would consolidate previously pre-allocated instruments, including the ERDF, ESF+, Cohesion Fund, EAFRD, EAGF and EMFAF. This fund would be implemented through a single National and Regional Partnership Plan per Member State, with the aim of enhancing the strategic coherence, impact and efficiency of EU budgetary investments (EC, 2025b). The Commission highlights several expected improvements stemming from this reform, including greater flexibility in resource use, enhanced integration and coordination among funding instruments, and a shift towards more decentralised decision-making in the allocation of financial resources. However, this proposal has raised significant concerns within the European Parliament and among rural stakeholders, particularly regarding the future of support for rural areas. A key issue identified is the limited advocacy capacity of rural actors, which may place them at a disadvantage in a governance framework increasingly reliant on national-level intergovernmental negotiations. In such a context, the risk emerges that rural priorities – especially those of demographically and economically fragile areas – may be underrepresented or deprioritised in the allocation of resources within the integrated national plans.

As highlighted in the previous sections, even during the current programming period, urban areas continue to demonstrate a stronger capacity to absorb EU funds than rural areas. Looking ahead, the proposed reforms to the EU policy framework may pose significant challenges for rural areas in accessing both cohesion and rural development resources, particularly depending on the share of funding allocated to these areas at the national level. The proposed reduction of the agricultural budget – estimated at approximately €30 billion – also raises concerns about potential cuts to territorial investments, which are crucial for addressing structural and demographic challenges in rural regions. To mitigate the risk of exacerbating territorial disparities, it appears essential to align with the European Parliament's position, which advocates maintaining the two-pillar structure of the CAP. This structure ensures a balance between market and production-oriented measures under Pillar I and the social and territorial development objectives of Pillar II (Matthews, 2025).

In addition, the proposed Common Provisions Regulation (EC, 2025b) should incorporate more effective mechanisms for fund integration, specifically targeting shrinking rural areas. This includes reinforcing place-based approaches such as LEADER and Smart Villages and ensuring a minimum ring-fencing of resources for these areas within the broader National and Regional Partnership Plans. Such provisions are significant in light of the limited implementation of the community-led local development approach observed in several Member States during the current programming period (Kah *et al*., 2023).

Another important policy implication concerns the potential application of this analytical framework within rural proofing (RP) methodologies. RP is the systematic assessment of policy measures and legislative proposals for their potential impact on rural areas. This approach is expected to be operationalised in the post-2027 EU policy framework, with the EC supporting its implementation across all Member States (EC, 2025c). The core objective of RP is to evaluate the distributive effects of policies that are not explicitly targeted at rural regions, but which may nonetheless exert a significant influence on their socio-economic and territorial development. In this regard, a robust analysis of the spatial allocation of EU funds, combined with an understanding of the key factors that influence it, constitutes a fundamental step in the RP process. Such evidence-based assessment is essential to ensure that broader policy decisions do not inadvertently disadvantage rural areas and that their specific needs are adequately addressed within the evolving EU policy architecture.

AUTHOR CONTRIBUTIONS

Conceptualization: F.M. and G.D.F.; Methodology: F.M.; Software, Data Curation and validation: G.A.; Investigation: F.M and G.A.; Writing - Original Draft: F.M.; Writing –Review & Editing: F.M., G.D.F and G.A.; Funding Acquisition: F.M. and G.D.F; Resources: F.M. and G.D.F; Supervision: F.M.

REFERENCES

Anselin L. (2002). Under the hood issues in the specification and interpretation of spatial regression models. *Agricultural Economics*, 27: 247-267. DOI: https://doi.org/10.1111/j.1574-0862.2002.tb00120.x.

Bartolini F., Raggi M., Viaggi D. (2012). A spatial analysis of participation in RDP measures: A case study in Emilia Romagna Region. In *Proceedings of the 1st AIEAA Conference 'Towards a Sustainable Bio-Economy: Economic Issues and Policy Challenges'*, Trento, Italy, 4-5 June 2012; Italian Association of Agricultural and Applied Economics (AIEAA), Trento, Italy, 2012. DOI: https://ideas.repec.org/p/ags/aieacp/124103.html.

Brezzi M., Dijkstra, L., Ruiz V. (2011). *OECD extended regional typology: The economic performance of remote rural regions*, OECD Regional Development Working Papers, 2011/06, OECD Publishing. DOI: https://doi.org/10.1787/5kg6z83tw7f4-en.

Charron N., Dijkstra L., Lapuente V. (2015). Mapping the regional divide in Europe: A measure for assessing quality of government in 206 European regions. *Social Indicators Research*, 122: 315-346. DOI: https://doi.org/10.1007/s11205-014-0702-y.

Colantoni A., Halbac-Cotoara-Zamfir R., Halbac-Cotoara-Zamfir C., Cudlin P., Salvati L., Gimenez Morera A. (2020). Demo-graphic resilience in local systems: An empirical approach with census data. *Systems*, 8: 34. DOI: https://doi.org/10.3390/systems8030034.

Copus A., Kahila P., Fritsch M., Dax T., Kovács K., Tagai G., Weber R., Grunfelder J., Löfving, L., Moodie J., Ortega-Reig M., Ferrandis A., Piras S., Meredith D. (2020). *ESCAPE European shrinking rural areas: Challenges, actions and perspectives for territorial governance*, Final Report. https://www.espon.eu/sites/default/files/attachments/ESPON%20ESCAPE%20Main%20Final%20Report.pdf.

Crescenzi R., Giua M. (2016). The EU cohesion policy in context: Does a bottom-up approach work in all regions? *Environment and Planning A: Economy and Space*, 48(11): 2340-2357. DOI: https://doi.org/10.1177/0308518X16658291.

Defrancesco E., Gatto P., Runge F., Trestini S. (2008). Factors affecting farmers' participation in agri-environmental measures: A northern Italian perspective. *Journal of Agricultural Economics*, 59: 114-131. DOI: https://doi.org/10.1111/j.1477-9552.2007.00134.x.

European Commission (2020). *Report from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions on the impact of demographic change*, COM/2020/241 Final, Brussels.

European Commission (2023). *The impact of demographic change in a changing environment*, Commission Staff Working Document, SWD 21 Final, Brussels.

European Commission (2025a). *Communication from the Commission to the European Parliament, the European Council, the Council, the European Economic and Social Committee and the Committee of the Regions. A dynamic EU Budget for the priorities of the future*

– *The Multiannual Financial Framework 2028–2034*, COM/2025/570, Brussels, final/2,

European Commission (2025b). *Proposal for a regulation of the European Parliament and of the Council establishing the European fund for economic, social and territorial cohesion, agriculture and rural, fisheries and maritime, prosperity and security for the period 2028–2034 and amending Regulation (EU) 2023/955 and Regulation (EU, Euratom) 2024/2509*, COM/2025/565 final/2, Brussels.

European Commission (2025c). *A vision for agriculture and food shaping together an attractive farming and agri-food sector for future generations*, COM(2025) 75 final, Brussels.

European Parliament (2019). *Effectiveness of cohesion policy: Learning from the project characteristics that produce the best results*, Policy Department D for Budgetary Affairs Directorate General for Internal Policies of the Union, Brussels.

EUROSTAT (2021). *Applying the degree of urbanisation. A methodological manual to define cities, towns and rural areas for international comparisons*, European Union/FAO/UN-Habitat/OECD/The World Bank, Publications Office of the European Union, Luxembourg.

FAO (2020). *The state of food and agriculture 2020. Overcoming water challenges in agriculture*, FAO, Rome. DOI: https://doi.org/10.4060/cb1447en.

ISTAT (2024). *La Demografia delle Aree Interne: Dinamiche Recenti e Prospettive Future, Roma, 29 luglio*. https://www.istat.it/wp-content/uploads/2024/07/STATISTICA-FOCUS-DEMOGRAFIA-DELLE-AREE-INTERNE_26_07.pdf.

Kah S., Martinos H., Budzich-Tabor U. (2023). CLLD in the 2014–2020 EU programming period: An innovative framework for local development. *World*, 4: 122-139. DOI: https://doi.org/10.3390/world4010009.

Kline P., Moretti E. (2014). People, places, and public policy: Some simple welfare. economics of local economic development programs. *Annual Review of Economics*, 6: 629-62. https://eml.berkeley.edu/~pkline/papers/KM_ARE_2014.pdf.

LeSage J.P. (1997). Regression analysis of spatial data. *Journal of Regional Analysis and Policy*, 27: 83-94.

Mantino F., De Fano G., Asaro G. (2022). Analysing how the policy delivery system can affect territorial disparities in Italy: The case of investment support in rural areas. *Land*, 11, 1883. DOI: https://doi.org/10.3390/land11111883.

Mantino F., De Fano G., Asaro G. (2024). Evaluating the impact of long-term demographic changes on local participation in Italian rural policies (2014–2020): A spatial autoregressive econometric model. *Land*, 13, 1581. DOI: https://doi.org/10.3390/land13101581.

Marconi V., Raggi M., Viaggi D. (2015). Assessing the impact of RDP agri-environment measures on the use of nitrogen-based mineral fertilizers through spatial econometrics: The case study of Emilia-Romagna (Italy). *Ecological Indicators*, 59: 27-40. DOI: https://doi.org/10.1016/j.ecolind.2015.02.037.

Matthews A. (2025). *Fitting the CAP into the next MFF long-term budget*. https://capreform.eu/fitting-the-cap-into-the-next-mff-long-term-budget/

Münch A., Gorny H., Badouix M., Gaugitsch R., Dwyer J., Kubinakova K., Beck M., Van Bunnen P., Mantino F., Brkanovic S. (2024). *Study on funding for EU rural areas–final report*, European Commission, Directorate-General for Agriculture and Rural Development, Publications Office of the European Union, Luxembourg. https://data.europa.eu/doi/10.2762/901111.

OECD (2025). *Shrinking smartly and sustainably: Strategies for action*, OECD Rural Studies, OECD Publishing, Paris. DOI: https://doi.org/10.1787/f91693e3-en.

Öir Gmbh, CCRI, ADE S.A. (2020). *Impact of the CAP on territorial development of rural areas: Socioeconomic aspects evaluation support study final report*, European Commission B-1049, Publications Office of the European Union, Brussels.

Pascucci S., de-Magistris T., Dries L., Adinolfi F., Capitanio F. (2013). Participation of Italian farmers in rural development policy. *European Review of Agricultural Economics*, 40: 605-631. DOI: https://doi.org/10.1093/erae/jbt005.

Perpiña Castillo C., Ribeiro Barranco R., Curtale R., Kompil M., Jacobs-Crisioni C., Vallecillo Rodriguez S., Aurambout J.P., Batista e Silva F., Sulis P., Auteri D. (2024). Are remote rural areas in Europe remarkable? Challenges and opportunities. *Journal of Rural Studies*, 105(January): 1-27. DOI: https://doi.org/10.1016/j.jrurstud.2023.103180.

Rodríguez-Pose A., Di Cataldo M. (2015). Quality of government and innovative performance in the regions of Europe. *Journal of Economic Geography*, 15: 673-706. DOI: https://doi.org/10.1093/jeg/lbu023.

Rodríguez-Pose A., Garcilazo E. (2015). Quality of government and the returns of investment: Examining the impact of cohesion expenditure in European regions. *Regional Studies*. 49: 1274-1290. DOI: https://doi.org/10.1080/00343404.2015.1007933.

Rosina A., Impicciatore R. (2022). *Storia demografica d'Italia. Crescita, crisi e sfide*. Carocci editore, Roma.

StataCorp (2023). *Stata 18 spatial autoregressive models reference manual*. Stata Press: College Station, TX, USA, 2023. https://www.stata.com/manuals/sp.pdf.

Yang A., Rounsevell M., Haggett C., Piorr A., Wilson R. (2015). The use of spatial econometrics, stakeholder analysis and qualitative methodologies in the evaluation of rural development policy. *Journal of Environmental Assessment Policy and Management*, 17(02), 1550023. DOI: https://doi.org/10.1142/S1464333215500234.

Yang A.L., Rounsevell M.D.A., Wilson R.M., Haggett C. (2014). Spatial analysis of agri-environmental policy uptake and expenditure in Scotland. *Journal of Environmental Management*, 133: 104-115. DOI: https://doi.org/10.1016/j.jenvman.2013.11.038.

Zasada I., Piorr A. (2015). The role of local framework conditions for the adoption of rural development policy: An example of di-versification, tourism development and village renewal in Brandenburg, Germany. *Ecological Indicators*, 59: 82-93. DOI: https://doi.org/10.1016/j.ecolind.2015.02.002.

APPENDIX

Table A.1. List of independent variables (descriptions and statistics).

Variable name	Variable description	Min	Max	Mean	Standard deviation
Demographic typology					
Growing urban	Dummy variable = 1 if municipality belongs to growing urban group, 0 to the mixed urban	-	-	-	-
Shrinking urban	Dummy variable = 1 if municipality belongs to shrinking urban group, 0 to the mixed urban	-	-	-	-
Growing rural	Dummy variable = 1 if municipality belongs to growing rural group, 0 to the mixed urban	-	-	-	-
Mixed rural	Dummy variable = 1 if municipality belongs to mixed rural group, 0 to the mixed urban	-	-	-	-
Shrinking rural	Dummy variable = 1 if municipality belongs to shrinking rural group, 0 to the mixed urban				
Territorial disparities					
Capital_cities	Dummy variable= 1 if municipality is a capital city of region/province, 0 otherwise	-	-	-	-
Lg_accessibility	Weighted average index of the proximity to services of each municipality (2020)	-13.78	0.90	-0.21	0.70
Lg _Broadband speed	Broad band speed from the fixed network (Mb/s) at municipal level (2020)	0.18	475.95	56.18	44.27
Lg_migrationrate	Net total migration rate per 1,000 inhabitants at the municipal level (2021)	-133.33	102.15	2.53	12.93
Lg_jobseekers	People in search for a job per 1,000 inhabitants at the municipal level (2019)	0.00	17.49	5.22	2.40
Lg_oldagerate	Population >= 65/population 15–64 per 100 inhabitants (2021)	12.94	150.00	42.42	11.53
Agricultural area					
Lg_shareagricarea	Share of total agricultural area on municipal area (%, 2020)	0.00	100.00	49.76	35.64
Lg_productivityha	Average Agricultural Standard Output per farm (Euro) (year 2015)	284.0	3,074,000	50,152	97,268
Fund efficiency					
Lg_Administrative efficiency	Efficiency score ERDF calculated at the municipal level	-6.54	377.14	0.00	13.93
	Efficiency score ESF calculated at the municipal level	-207.49	417.61	0.00	129.28
	Efficiency score EAFRD calculated at the municipal level	-4.81	96.70	0.00	4.90

Source: All data are compiled from various sources like Central Institute of Statistics (ISTAT), OPENCOESIONE, own survey on EAFRD-funded projects.

REA | ITALIAN REVIEW OF AGRICULTURAL ECONOMICS

Firenze University Press
www.fupress.com/rea

OPEN ACCESS

Citation: Cavallo, A., Cannata, G., Mastronardi, L., & Romagnoli, L. (2025). Environmental vulnerability in Italian mountain areas and its socioeconomic drivers. *Italian Review of Agricultural Economics* 80(3): 61-75. DOI: 10.36253/rea-16630

Received: August 21, 2025

Revised: December 16, 2025

Accepted: December 16, 2025

Data Availability Statement: Data will be made available by the corresponding author upon request.

Competing Interests: The Author(s) declare(s) no conflict of interest.

Guest Editor: Francesco Mantino

ORCID
AC: 0000-0002-6896-141X
GC: 0000-0001-8383-4809
LM: 0000-0001-6012-2964
LR: 0000-0003-3243-1561

Research article

Environmental vulnerability in Italian mountain areas and its socioeconomic drivers

Aurora Cavallo[1,*], Giovanni Cannata[1], Luigi Mastronardi[2], Luca Romagnoli[3]

[1] *Department of Economics, Statistics and Business, Universitas Mercatorum, Italy*
[2] *Department of Biosciences and Territory, University of Molise, Campobasso, Italy*
[3] *Department of Economics, University of Molise, Pesche (IS), Italy*
*Corresponding author. E-mail: a.cavallo@unimercatorum.it

Abstract. Mountain areas are exposed to multiple risks due to the complex interactions between environmental, social, and economic factors. This paper aims to assess the environmental vulnerability of mountain areas through a synthetic indicator and to identify the drivers of such vulnerability at the local level. It uses a multidimensional and spatial approach to define the main dimensions of vulnerability based on municipal data. Furthermore, a geographically weighted regression model is used to investigate the drivers of vulnerability. The results show that mountain areas are less environmentally fragile than lowland and hilly regions but have higher demographic, social, and economic vulnerability. However, southern mountains are more fragile due to the lower presence of protected areas and forest cover. The spatial model also reveals a trade-off between environmental preservation and demographic, social, and economic characteristics. These findings should be carefully considered in light of place-based planning strategies and policies in mountain areas, particularly in southern Italy.

Keywords: vulnerability, composite indicators, spatial analysis, GWR model, planning.
JEL codes: Q15, Q18, R58.

HIGHLIGHTS

- Mountain areas are prone to multiple environmental hazard factors
- A vulnerability index to analyse the environmental state of Italian mountain is defined
- Several socio-economic drivers are investigated at the spatial scale
- Mountain areas show a healthier environmental condition than hill and plain zones, with a trade-off between environment and socio-economic features
- The research findings provide useful insights for planning strategies

1. INTRODUCTION

Research on human-environment vulnerability primarily considers large-scale environmental processes (Cutter *et al*., 2014; UNDRO, 1979) and identifies various areas of vulnerability, including economic, social, and environmental factors, as well as the complex relationships linking these factors to risk (Cutter, 2021). The spatial variation of vulnerability and the factors that cause it is pivotal to the development of policy measures aimed at strengthening the resilience of the most exposed communities (UNISDR, 2015). Vulnerability can be conceptualised as the consequence of multiple spatial marginalities that are interdependent in their dynamic evolution (Vendemmia *et al*., 2021). This approach facilitates the identification of differential degrees of spatial marginality, which is instrumental in the recognition of varied intensities and manifestations of vulnerability, thus enabling the formulation of targeted spatial policies (OECD, 2022). While this issue has been investigated more extensively in urban areas (Sun *et al*., 2022), vulnerability analysis remains a crucial aspect in marginal areas, particularly mountain areas, which are more exposed to environmental risks (Karpouzoglou *et al*., 2020).

Vulnerability is a multidimensional concept (Bernués *et al*., 2022; Ford *et al*., 2018) linked to a population's exposure to hazards and its ability to respond to and recover from the impacts of such risks (Thorn *et al*., 2020). Mountain communities have different capacities for resilience and recovery depending on their social and economic conditions (Jha *et al*., 2021). Therefore, in mountain areas, the incidence of multi-risk events and the causal links between risks are often deeply intertwined (Schmeller *et al*., 2022). For example, earthquakes can trigger secondary processes such as avalanches or landslides, and droughts are deeply linked to fires. Multi-hazard risks pose a major challenge because they are expected to increase in intensity and frequency with global warming (Bankoff, Hilhorst, 2022). These risk categories need to be analysed separately because manageable threats can be addressed, while unavoidable ones can only be mitigated and are generally associated with environmental risks (Mastronardi *et al*., 2022).

Multiple pressures have affected mountain areas in recent decades, including demographic decline and depopulation (González-Leonardo *et al*., 2022), abandonment of agricultural activities (Levers *et al*., 2018), and the dependence of local economies on tourism (Teare, 2021). Since the 1950s, Italian mountains have experienced a demographic decline and population ageing, leading to an uneven socio-economic fabric and a severe lack of essential services. These conditions favour a vicious circle which accelerates population abandonment, reduces economic activities, and leads to the disintegration of the social fabric and the increase in land management costs (Pagliacci, Russo, 2019).

Italian mountain areas have multiple vulnerabilities. The impact of earthquakes is often devastating, and the fragile socio-economic structure of these places emerges as a critical factor in earthquakes, particularly in the Apennine areas (Pagliacci *et al*., 2021). Landslides have a significant impact in terms of loss of life and natural resources (Trigila, Iadanza, 2018), which can be exacerbated by the impact of climate change in inner areas, both in terms of frequency (Gariano *et al*., 2018) and intensity (Esposito *et al*., 2023). These events are also linked to the abandonment of agriculture, which has accelerated in mountain areas (Dax *et al*., 2021), leading to changes in land use and forest cover (Rumpf *et al*., 2022). These changes have been confirmed by future change models (Gobiet, Kotlarski, 2020).

Italian mountain areas have the highest percentage of forests and protected areas in the country, along with lower levels of air pollution and land consumption (Uncem, 2025). Forests provide ecosystem services and socio-economic benefits (Dasgupta, 2021), and contribute to climate change mitigation (Callisto *et al*., 2019). Protected areas play a crucial role in biodiversity conservation and sustainable development (Acreman *et al*., 2020). Mountains are socio-ecological systems whose management and conservation are linked to human activity (Bretagnolle *et al*., 2019). As such, they have a positive impact on the provision of ecosystem services (Kokkoris *et al*., 2018), income (Sena-Vittini *et al*., 2023), and employment (Acampora *et al.,* 2023) through the enhancement of tourism (Lenart-Boroń *et al.,* 2021), and sustainable, quality-conscious agricultural practices (Romano *et al*., 2021).

The relationship between socio-economic factors and environmental conditions is crucial in mountain areas. The weakness of socio-economic factors, such as depopulation, ageing, a decline in employment, and the cessation of business activities, impacts the abandonment of territory (Urso *et al*., 2019). Consequently, these areas are subjected to environmental vulnerability (i.e., landslides and hydrogeological instability), thereby increasing remoteness (Di Giovanni, 2016; Pilone, De Michela, 2018). Many economic and social indicators can contribute to the measurement of vulnerability, but there are still research gaps regarding the identification of indicators that allow for the measurement of when a population or area is exposed to multiple environmental risks (Cong *et al*., 2023). This requires the need of appropriate spatial scales, including the local ones, to effectively address risk management and the concerns of stakeholders and local communities (Marsden, 2024).

The aims of the study are (1) to assess the environmental vulnerability of mountain areas through the definition of a synthetic indicator; and (2) to identify the drivers of such vulnerability at local level. This study addresses some gaps in the literature by using a multidimensional and spatial approach that has been less explored in the literature (Drakes, Tate, 2022; Schmeller *et al*., 2022), especially in mountain areas, which are more exposed to multiple risk and threat factors (Eckstein *et al*., 2021). The distinctive contribution of this research lies in the integration of environmental and socio-economic vulnerability at a spatial level, a critical aspect of human-environment interactions, into the assessment of mountain exposure to environmental risks (Pirasteh *et al*., 2024).

The remainder of this paper is organised as follows. Section 2 describes the data and methods used for our analysis. Sections 3 and 4 present the results and discuss them. Finally, Section 5 provides the conclusions.

2. DATASET AND METHODS

2.1. Dataset and variables definition

To construct a composite vulnerability index, we analysed the available datasets on the selected variables for the Italian municipalities. On 1 January 2019, Italy was subdivided into 7960 municipalities; our data refer to 7942 of them, due to missing data for the remaining 18. Our interest is in mountain areas, comprising 2514 municipalities classified as "Inner Mountain" (2397) or "Coastal Mountain" (117) by the Italian National Institute of Statistics (Istat).

The variables and indicators considered are reported in Table 1. Apart from previous considerations described in Section 1, the selection of variables integrates environmental and socio-economic aspects to ensure a comprehensive assessment of the multiple factors that shape vulnerability when using a spatial approach. Nevertheless, the choice of variables was heavily conditioned by the information available at the municipal level. We used the most recently data available for 2017-2019, with the exception of data pertaining to the 2020 so-called National Strategy for Inner Areas (IANS). When necessary, we normalised the original variables to eliminate the scale effects deriving from the very different size of the municipalities.

We considered the impact of variables on the environmental, demographic, social and economic domains to justify their inclusion. The effects and related literature are reported in Table 2.

The methodological approach consists of two phases, related to the two goals stated at the end of Section 1. They are described in the following subsections.

2.2. Derivation of the synthetic indexes

The first phase involved nine variables related to the environmental domain (Table 1). We maintained the original value (level of risk) of the indicators *earthquake hazard* (*EH*) and *particulate matter pollution* (*PM*10) and considered them quantitative variables. We derived *landslide hazard* (*LH*), *flood hazard* (*FH*), *land consumption* (*LC*), *protected areas* (*PA*), and *forest areas* (*FA*) by dividing the original values by the corresponding municipal areas. *Waste collection* (*WA*) is the annual waste per inhabitant (in kilograms). Finally, we calculated *monthly average precipitation* (*A_SPI*; the Abnormal Standardised Precipitation Index) as follows. The *standardised precipitation index* (*SPI*) was determined as *SPI*-12 (12 months of accumulation) (Bordi *et al*., 2007) over a 30-year period and after the time series (one for each municipality). Then, we calculated the fraction of times for which $|SPI| > 1.5$: $A\_SPI = \frac{\#|SPI|>1.5}{360}$, giving the same consideration to drier and wetter periods when defining its contribution to vulnerability.

We used the aforementioned indicators to build the *synthetic environmental vulnerability index* (*SEVI*). Seven of the indicators have a direct relationship to *SEVI*; this means that an increase of an indicator leads to an increase in *SEVI*, and vice versa. *FA* and *PA*, however, are inversely linked to environmental vulnerability. Therefore, we modified their original values, denoted by FA_i and PA_i, to become $FA_{inv,i} = 1 - FA_i$ and $PA_{inv,i} = 1 - PA_i$, which range from 0 (no vulnerability, when the whole municipal territory is covered by forests and/or protected areas) to 1 (maximum vulnerability, in the absence of forests and/or protected areas). We also standardised all indicators to give each the same weight. The resulting index is defined for the *i*-th municipality ($i = 1,...,7942$) as the mean $SEVI_i = \frac{\sum_{j=1}^{9} ZI_{j,i}}{9}$, where ZI_j is the *j*-th standardised indicator. By definition, *SEVI* has a mean of 0 and variance that is less than 1 (because it is a linear combination of correlated standardised variables).

For the second phase, we built three more synthetic measures that can be considered proxies for the demographic, social, and economic features of Italian municipalities. We used them to analyse the relationships among environmental vulnerability, as expressed through the *SEFI* measure, and the socio-economic fabric at a local scale.

Table 1. Original variables and indicators employed in the analysis, per domain.

Variable	Source*	Indicator	Acronym	Domain**
Earthquake hazard	INGV	Earthquake hazard classification	*EH*	Environment
Landslide hazard	ISPRA	Share of landslide hazard areas	*LH*	Environment
Flood hazard	ISPRA	Share of flood hazard areas	*FH*	Environment
Monthly average precipitation	CRU-UEA	Abnormal Standardised Precipitation Index	*A_SPI*	Environment
Particulate matter pollution	ISPRA	Particulate matter pollution	*PM10*	Environment
Waste collection	ISPRA	Per capita waste collection	*WA*	Environment
Land consumption	ISPRA	Share of land consumption	*LC*	Environment
Forest areas	CLC	Share of forest areas	*FA*	Environment
Protected areas	UN-WCMC	Share of protected areas	*PA*	Environment
Population aged 80+	Istat	Share of population aged 80+	*EP*	Demography
Births and deaths	Istat	Natural growth rate	*NGR*	Demography
Degree of urbanisation	Istat	(Modified) Population density	*MPD*	Society
IANS	Istat	Time of travel to the nearest Pole	*TNP*	Society
Local units	Istat	Local units per 1000 residents	*UL*	Economy
Employees	Istat	Employees per 1000 residents	*EMP*	Economy

Note: *INGV, Italian Institute of Geophysics and Volcanology; ISPRA, Italian Institute for Environmental Protection and Research; CRU-UEA, Climatic Research Unit – University of East Anglia; CLC, Corine Land Cover; UN-WCMC, UN Environment Programme – World Conservation Monitoring Centre; Istat, Italian National Institute of Statistics.
** Each background colour refers to a different synthetic index (described in Section 2.2). Green: *SEVI*; light orange: *DWI*; orange: *SDI*; light blue: *EWI*.

Table 2. The effects of the employed variables as deduced from the literature.

Variable	Effects	Reference literature
Earthquake hazard	Damage to buildings, Infrastructure, and people	European Commission, 2021
Landslide hazard / flood hazard	Modify the natural environment and hit communities as a whole	Aroca *et al.*, 2022; Trigila, Iadanza, 2018
Monthly average precipitation	Too much rain triggers floods and landslides Long-term dryness: soil erosion, salinisation, and land degradation	European Environment Agency, 2020
Particulate matter pollution	Danger to human health, especially in urban areas	Brooks, Sethi, 1997
Waste collection	Negative effects on air, soil, and water pollution	ISPRA, 2020
Land consumption	Non-reversible soil use or transformation	ISPRA, 2018
Forest areas	Carbon dioxide capture, release of water vapour, conservation of plant and animal life and reduction of hydrogeological risk	IPCC, 2023
Protected areas	Biodiversity and ecosystem conservation	Geldmann *et al.*, 2013; Stolton *et al.*, 2015
Population aged 80+ years	Low dynamism and less available workforce	Mottet et al., 2006
Births and deaths	Demographic decline, abandonment of productive activities, and loss of social capital	Jha *et al.*, 2021; Pilone, De Michela, 2018
Degree of urbanisation	Rurality condition and economic disadvantage	De Rossi, 2018
Distance from the nearest Pole	Remoteness from essential public services	Uval, 2014
Local units	Resilience and vitality of the productive fabric	Urso *et al.*, 2019
Employees	Vitality of social capital	Faggian *et al.*, 2018

The *demographic weakness index* (*DWI*) includes the share of population aged 80+ years and the natural growth rate. The latter is defined as the difference between the number of births and deaths in a given year, divided by the average amount of the resident population and multiplied by 1000.

The *social disadvantage index* (*SDI*) is defined as vulnerability caused by the scarcity of so-called essential services (health, education, and mobility services). Thus, this index can be based on the degree of urbanisation and the IANS classification, as both reflect social distress due to a lack of services. The degree of urbanisation is expressed through transformation of the population density (*PD*). Because *PD* is hypothesised to be inversely linked to the presence of essential services, we first calculated the square root of *PD* to reduce the variability and then took the inverse of that result. Consequently, the modified population density employed is $MPD_i = 1/\sqrt{PD_i}$. With regard to the IANS classification, the indicator employed is the time of travel (by public transport), in minutes, to reach the nearest Pole (in the context of the IANS, a Pole indicates a municipality where all the essential services are present).

Finally, the *economic weakness index* (*EWI*) includes the number of local units of firms per 1000 residents and the number of employees per 1000 residents.

Just like for *SEVI*, we calculated *DWI*, *SDI*, and *EWI* by standardising each component. We employed the mean values of each index as independent variables in the local spatial model.

2.3. The spatial econometric model

As discussed in Section 1, the social, institutional, and economic characteristics of local communities directly influence the evolution of ecosystems and environmental condition (Carrer *et al.*, 2020; Jha *et al.*, 2021; Stotten *et al.*, 2021; Whitaker, 2023). To model this relationship, we used a geographically weighted regression (GWR) model (Fotheringham *et al.*, 2002). Given a set of multivariate observations, geographically set in *n* sites (or zones or locations), on *P* independent variables and one dependent variable, GWR belongs to the class of spatially varying coefficient (SVC) models. They consider spatial heterogeneity in the coefficients and are employed especially when large samples are available (Murakami *et al.*, 2020). Most of the approaches to SVC problems, however, are affected by the 'degeneracy problem': they use spatially varying local functions that are too smooth and produce map representations of the coefficients that fail to capture local-scale coefficient variations. Thus, GWR is a very useful tool because it is not affected by degeneracy. It allows for more realistic modelling of local characteristics based on the choice of several local kernels.

Formally, GWR is a non-parametric model based on a sequence of locally linear regressions, built to produce estimates for every point in space using a sub-sample of data information from nearby observations (LeSage, 2004). The GWR model gives rise to n distinct local regressions, one for each site. Drawing on Tobler's first law of geography (Tobler, 1970), which states that nearby phenomena tend to occur in a more similar way than distant ones, we adopted this local spatial model because estimating a single parametric value for the entire observed area – as in conventional (non-spatial) regression – would be impractical.

The observations in each of the distinct equations are based on a set of local weights. Hence, each observation has importance that decays as distance from site i under consideration increases. The i -th local GWR can be expressed, in matrix-vector form, as:

$$\boldsymbol{W}_i(b)\boldsymbol{y} = \boldsymbol{W}_i(b)\boldsymbol{X}\boldsymbol{\beta}_i + \boldsymbol{\varepsilon}_i \tag{1}$$

where $\boldsymbol{y} = [y_1, y_2, \dots, y_n]'$ is the $n \times 1$ vector of the dependent variable; $\boldsymbol{X} = [\boldsymbol{x}_0\boldsymbol{x}_1 \dots \boldsymbol{x}_P]$ is the $n \times (P+1)$ matrix of the independent variables, with $\boldsymbol{x}_0 = 1_n$, the $n \times 1$ vector of ones, in order to include in the equation, the intercept term $\beta_{i,0}$; $\boldsymbol{\beta}_i = [\beta_{i,0}, \beta_{i,1}, \dots, \beta_{i,P}]'$ is the $(P+1)$, a dimensional vector of the i -th local model parameters; $\boldsymbol{W}_i(b) = \mathrm{diag}(w_{i,11}(b), w_{i,22}(b), \dots, w_{i,nn}(b))$ is an $n \times n$ diagonal matrix that, in the j-th position of the main diagonal, contains the distance-based weight measuring the distance between observations at sites i and j; and $\boldsymbol{\varepsilon}_i$ is the error term relating to i-th local regression: $\boldsymbol{\varepsilon}_i \sim MVN(0, \sigma^2\boldsymbol{I}_n)$.

The (local) parameter estimates for the model in Equation (1) are obtained through weighted least-squares and written as:

$$\widehat{\boldsymbol{\beta}}_i = \left[\boldsymbol{X}'\boldsymbol{W}_i^2(b)\boldsymbol{X}\right]^{-1}\boldsymbol{X}'\boldsymbol{W}_i^2(b)\boldsymbol{y} \tag{2}$$

where, as usual, $\boldsymbol{X}'$ indicates the transpose of $\boldsymbol{X}$. The result in Equation (2) depends on a bandwidth, b, which characterises the chosen local kernel function and determines the weights to be assigned to the neighbouring observations of site i. The usual choice for the weights exploits Euclidean distance and a Gaussian distance-decaying kernel (Lu *et al.*, 2022):

$$w_{i,jj}\left(b\right) = \exp\left\{(-d_{ij}/b)^2\right\} \tag{3}$$

with d_{ij} representing the Euclidean distance between zones i and j. The choice of an optimal value for the bandwidth is a crucial point for any GWR. The task is typically solved by means of a leave-one-out cross-validation (LOOCV) procedure to minimising the cross-validation score, *CV*: $CV = \sum_{i=1}^{n}\left[y_i - \hat{y}_{-i}\left(b\right)\right]^2$, where $\hat{y}_{-i}(b)$ is the fitted value for y_i which derives from an estimation procedure leaving out the i-th observation.

The LOOCV step is computationally very demanding, as are also the calculations required by the diagnostics, commonly based on an adjusted R^2 (R^2_{adj}) and/or a corrected Akaike information criterion (*AICc*). These steps involve a high number of repeated calculations on large matrices, which often makes the use of a

GWR unfeasible in the presence of big databases. For these reasons, many possible alternatives to 'classical' GWR have been proposed in the scientific literature (for a review and comparison among different methods, see Lu *et al.*, 2022).

To analyse our data, we chose to employ the scalable GWR model (ScaGWR) proposed by Murakami *et al.* (2020). This method replaces the standard non-linear kernels present in GWR analysis with a linear multiscale kernel of the form:

$$w_{i,jj}^{(ScaGWR)}(\alpha,\gamma) = \alpha + \sum_{k=1}^{K}\gamma^k\left[w_{i,jj}^{(Q)}\left(b^*\right)\right]^{4/2k} \quad (4)$$

where $w_{i,jj}^{(Q)}(b^*)$ is a base kernel, assumed to be a decreasing function of distance d_{ij} and have a value of 1 for d_{ij}} = 0; b^* is a fixed bandwidth; K is the maximum order of the polynomials defining the multiscale kernel; and Q is the number of neighbours of site i, a fixed number for every local kernel of the type in Equation (4). It is used to determine the threshold for the base kernel. Letting $d_{i(Q)}$ be the distance between site i and its Q -th nearest neighbour, it will be $w_{i,jj}^{(Q)}\left(b^*\right) = w_{i,jj}(b^*)$ if $d_{ij} \leq d_{i(Q)}$, and $w_{i,jj}^{(Q)}\left(b^*\right) = 0$. Having fixed b^*, K, and Q, the estimated parameters are α, a *global* weight parameter, and γ,which weights the *local* terms of Equation (4).

There are two especially relevant advantages of the ScaGWR model. First, it drastically reduces the computational burden to find parameter estimates. Specifically, $w_{i,jj}^{(ScaGWR)}(\alpha,\gamma)$ are defined at a cost of complexity $O(nQ)$ instead of $O(N^2)$, and the LOOCV procedure for estimating α and γ has a cost, which is quasi-linear with respect to n. Second, *ad hoc* simulations have highlighted that the local parametric estimates obtained through ScaGWR are at least as good, in terms of the root mean square error (RMSE), as those obtained through classical GWR. This means that they can be usefully employed in cases like ours: with an n close to 8000, there can be problems in running a standard GWR algorithm.

3. RESULTS

Table 3 reports the mean values of the environmental indicators introduced in Table 1. Mountain areas show the highest values for *EH*, *LH*, *FA*, and *PA*. However, they show the lowest values for *PM*10 and *LC*, indicators that are related to a better environmental condition. The remaining indicators for the mountain areas are near or equal to the national mean. Maps showing the geographical distribution of the original indicators in Mountain Areas (MAs) are reported in Figure A.1 in the Appendix.

Table 4 shows the *SEVI* median, mean, and standard deviation (SD) for each altimetric zone and for Italy as a whole. *SEVI* decreases gradually when moving from plain to hill to mountain areas. Within the individual zones, the variability is quite high, as indicated by the SDs.

At the municipal level, Figure 1 illustrates the *SEVI* values for mountain areas. There are some critical situations in north-western Italy, and some in the central and southern parts of the country.

Table 5 provides details for the municipalities with a *SEVI* > 0 (i.e., the most fragile ones). There is still an apparent decrease in terms of the percentage of municipalities involved and their surface area when going from plain to mountain areas. The population living in fragile areas is higher in hill municipalities in both absolute and relative terms.

Notably, although mountain areas exhibit the lowest overall incidence of environmental fragilities, approximately one quarter of their municipalities are affected. These municipalities account for only 11.21% of the total surface area, yet they host a substantial share of the population, comparable to the national average.

For our second aim, we first derived the demographic, social, and economic variables to build the covariates of model (1); their mean values are presented in Table 6. Focusing on mountain areas, it is evident that the situation here is the worst. From a demographic point of view, mountain areas have the highest (absolute) values for *EP*

Table 3. Mean values of the environmental indicators employed in this study.

Altimetric zone	EH	LH	FH	A_SPI	*PM*10	WA	LC	FA	PA
Plain	5.50	0.09	0.14	0.13	3.60	476.43	0.17	0.05	0.06
Hill	6.96	0.47	0.16	0.14	2.19	427.25	0.10	0.25	0.14
Mountain	7.19	0.54	0.15	0.13	1.64	455.01	0.04	0.61	0.27
Italy	*6.64*	*0.39*	*0.15*	*0.14*	*2.39*	*449.02*	*0.10*	*0.31*	*0.16*

Note: *EH* is based on four-class classification (low, medium, high, very high). *LH* is the share of landslide hazard municipal areas. *FH* is the share of flood hazard municipal areas. *A_SPI* is the fraction of times (over a 30-year period) for which the Standardised Precipitation Index exceeds the value of 1.5. PM_10 is presented as μg/m^3. *WA* is presented as kilograms per capita. *LC* is the share of municipal land consumption. *FA* is the share of forest municipal areas. *PA* is the share of protected municipal areas.

Table 4. Descriptive statistics for the Synthetic Environmental Vulnerability Index (*SEVI*).

Altimetric zone	Median	Mean	SD
Plain	0.178	0.193	0.274
Hill	0.067	0.043	0.336
Mountain	-0.212	-0.220	0.330
Italy	*0.022*	*0.000*	*0.357*

Table 5. The main features of municipalities with a Synthetic Environmental Vulnerability Index (*SEV*) > 0.

Altimetric zone	Number of municipalities	Surface area (km^2)	Population
Plain	1650 (78.31)	32,666.95 (46.75)	9,909,398 (33.49)
Hill	1912 (57.57)	41,763.60 (33.34)	11,150,821 (47.58)
Mountain	642 (25.54)	11,916.28 (11.21)	2,925,309 (39.60)
Italy	*4204 (52.93)*	*83,346.83 (28.64)*	*23,985,528 (39.70)*

Note: the percentage is presented in parentheses.

and *NGR*, meaning that the percentage of population aged 80+ years is the highest while the natural growth rate is the lowest. Mountain areas also have the highest values for the variables that indicate the degree of urbanisation and remoteness (*MDP* and *TNP*, respectively). This means that in these areas there is a high presence of municipalities that are scarcely populated ($MDP \geq 0.08$ km^2/inhabitant, i.e., $PD \leq 150$ inhabitant/km^2), which can be considered rural areas (Eurostat, 2025). There are also a higher proportion of inner area municipalities which are distant from the nearest Pole, where public and private services are limited or totally lacking.

Table 7 shows the descriptive statistics of the independent variables in our ScaGWR model (1) by altimetric zone. Mountain areas present the highest medians for all three indexes, meaning that these areas are characterised by strong demographic, social, and economic weaknesses. The high SDs, especially for demographic and economic dimensions, indicate a certain amount of internal variability. Thus, mountain areas likely experience different scenarios.

Figure 2 displays the spatial distribution of the three aforementioned indexes in mountain areas. At a local scale, *DWI* and *EWI* exhibit a clear increasing gradient moving from northern to southern Italy (with a few exceptions for *DWI* in the most southern part of the

Figure 1. Spatial distribution of the Synthetic Environmental Vulnerability Index (*SEVI*) in Italian mountain areas.

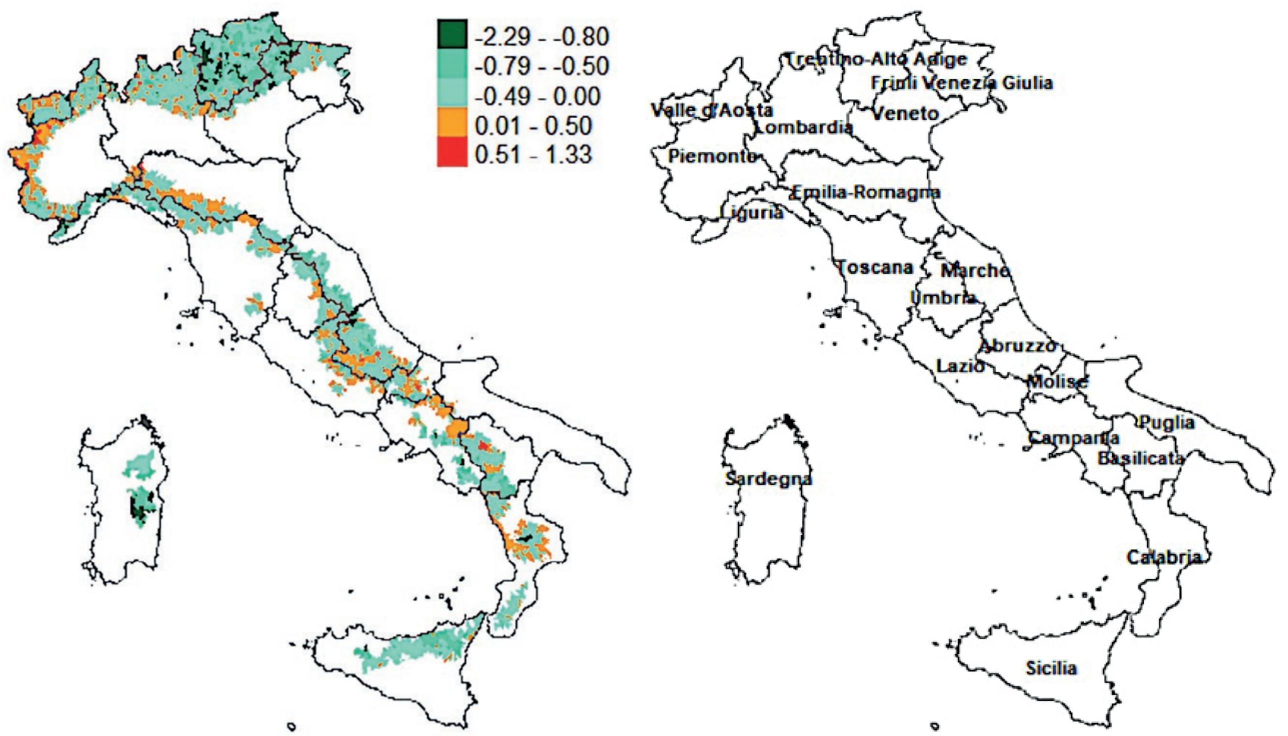


Table 6. Mean values of the demographic, social and economic variables by altimetric zone

Altimetric zone	EP	NGR	MDP	TNP	UL	EMP
Plain	5.90	-3.44	0.07	19.37	6.71	26.55
Hill	7.35	-6.10	0.10	30.22	6.49	19.96
Mountain	8.15	-7.70	0.18	41.59	6.74	19.31
Italy	*7.22*	*-5.90*	*0.12*	*30.93*	*6.63*	*21.50*

country). There is much more widespread heterogeneity for *SDI*, which does not display any particular clusters but does show the presence of a majority of municipalities where essential services are absent.

The most important calculation regarding the ScaGWR model involves the linear multiscale kernel defining the model weights, as shown in Equation (4). Thus, by defining $d_{(Q)}^{med}$ as the median of the *Q*-nearest neighbour distances and following the algorithm proposed by Murakami *et al.* (2020), we set $b^* = 3^{-\frac{1}{2}} \bullet d_{(Q)}^{med}$. For the two remaining parameters to be fixed in Equation (4), that is *K* (the maximum order of the polynomials) and *Q* (the number of neighbours), we tried different combinations and compared the results based on *AICc* and R_{adj}^2. The best combination was *K* = 3 and *Q* = 150. Figure 3 presents the main results for the estimated model (1). In particular, values for the parametric estimates of the single independent variables are displayed and only coefficients that are significant at the 5% level are shown.

In Figure 3a, the significant positive relationship linking *DWI* and *SEVI* is evident in many northern Italian municipalities. This could be due to the effect of the negative values expressing minor environmental vulnerability and the contextual negative *DWI* values present in the majority of these municipalities. This is the best possible combination because demographic vitality favours a healthy environment (Pilone, Demichela, 2018; Stotten *et al*., 2021). There is an exception in some parts of the Trentino-Alto Adige region: although *SEVI* and *DWI* have the same sign, the corresponding model coefficients are negative, suggesting that in this part of the country a favourable demographic status does not improve the state of the environment. Central Italy is characterised by a mainly inverse relationship between demographic weakness and environmental vulnerability. Most of the municipalities present a favourable environmental situation, indicating that they are experiencing depopulation and/or ageing phenomena. The estimated coefficients for southern Italy are mainly negative. However, it is worth noting the positive cluster between the Molise, Campania, and Basilicata regions, which is the result of the worst possible combination – have high values for both *DWI* and *SEVI*.

The map concerning *SDI* (Figure 3b) shows that almost all of the coefficients have a negative sign. remember that this indicates an inverse link between *SDI* and *SEVI*, apart from the algebraic values taken by the variables. Because the dependent variable, *SEVI*, is mostly lower than the mean, it follows that, as expected, rural and inner area municipalities are characterised by a higher *SDI*. This means that municipalities where essential services (health, education, and mobility) are lacking still exhibit a favourable environmental state.

Finally, the parametric estimates for *EWI* in Figure 3c indicate that there is a trade-off between economic activities and environmental state. Similarly to *DWI*, the Trentino-Alto Adige region stands out as a situation that is potentially very favourable, but this is not confirmed by the model results: the negative coefficient estimates do not seem to allow for good compatibility between the economy and the environment.

4. DISCUSSION

Large portions of Italian mountain areas are characterised by social, economic, and demographic vulnerability. In terms of environmental vulnerability, apart from seismic and landslide risks, the overall environmental conditions are better thanks to the presence of vast wooded areas, extensive protected areas, lower atmospheric pollution, and less land consumption. These results reveal local diversity at a detailed administrative

Table 7. Descriptive statistics of the independent variables in model (1) by altimetric zone

Altimetric zone	*DWI*			*SDI*			*EWI*		
	Median	Mean	SD	Median	Mean	SD	Median	Mean	SD
Plain	-0.46	-0.41	0.66	-0.44	-0.55	0.71	-0.09	-0.18	0.88
Hill	-0.09	0.04	0.81	-0.09	-0.00	0.83	0.23	0.08	0.83
Mountain	0.12	0.30	1.11	0.58	0.46	0.70	0.26	0.05	1.01
Italy	*-0.15*	*0.00*	*0.93*	*-0.09*	*0.00*	*0.85*	*0.14*	*0.00*	*0.91*

Figure 2. Spatial distribution of the (a) Demographic Weakness Index (*DWI*), (b) Social Distress Index (*SDI*), and (c) Economic Weakness Index (*EWI*) in Italian mountain areas.

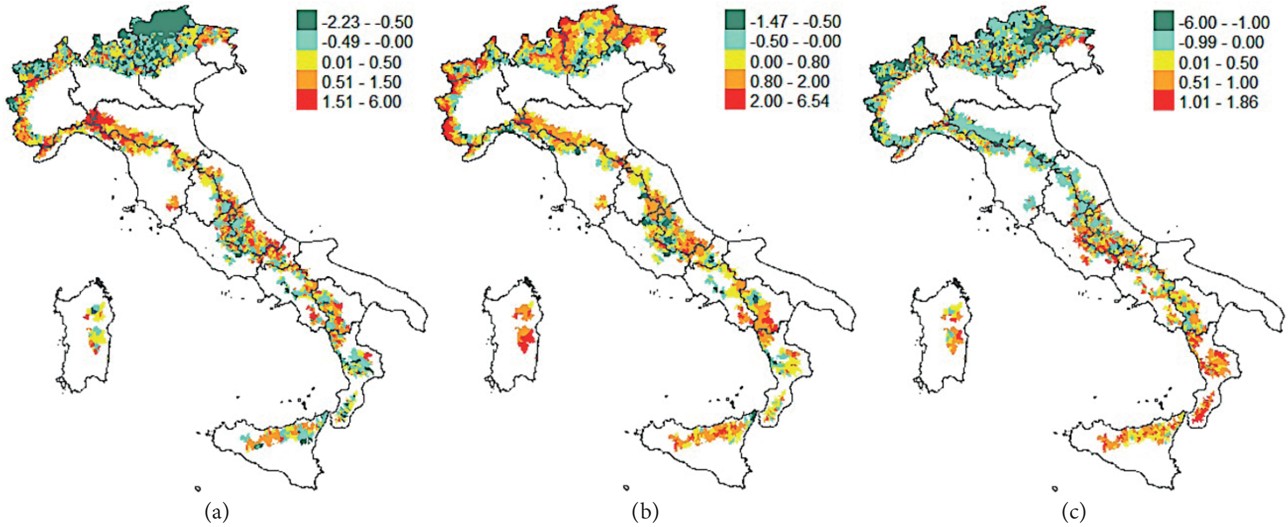
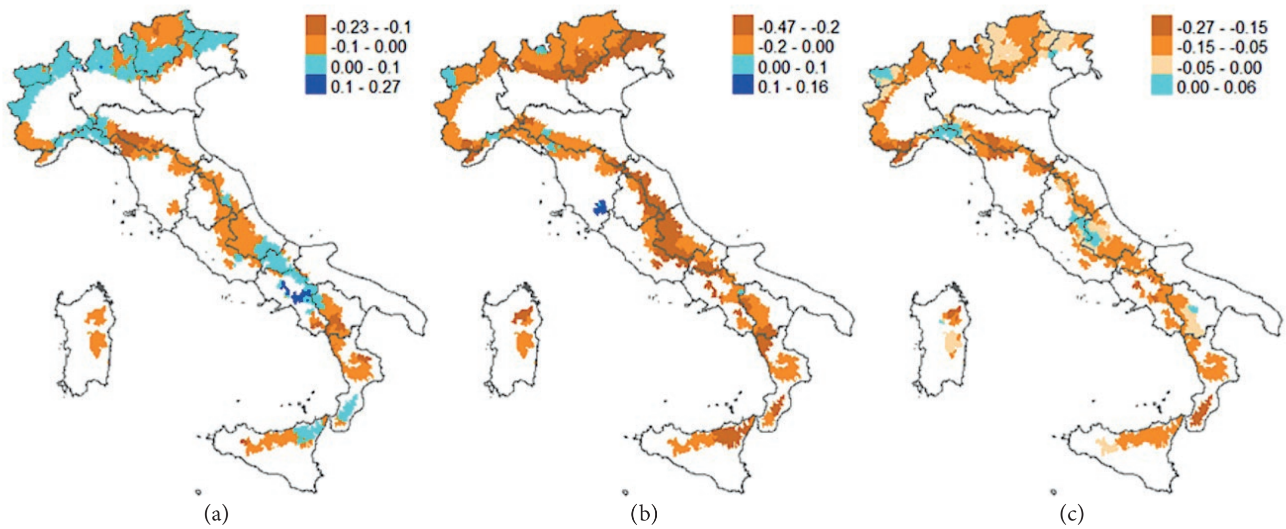


Figure 3. Values for the (a) Demographic Weakness Index (*DWI*), (b) Social Distress Index (*SDI*), and (c) Economic Weakness Index (*EWI*) in model (1) that are significant at the 5% level.



level, highlighting the role of a local approach to territorial vulnerability analysis (Shepherd, Dissart, 2022). This evidence reveals diversity at the local level on a detailed administrative scale, highlighting the need for a local approach to analysing territorial vulnerability. At a local level, there is some critical vulnerability in north-western Italy and, to a lesser extent, in some parts of central and southern Italy. In Piedmont, these vulnerabilities stem from demographic and environmental issues and the role of local mountain policies, which are characterised by deep fragmentation (Chilla *et al*., 2018). In both the southern Apennine areas and the Piedmont section, demographic and economic decline has been observed as confirmed by the recent Uncem (2025) report.

The results reveal strong demographic, social, and economic weaknesses. This dynamic can be explained by considering how population ageing is linked to less autonomy, with birth and mortality rates being an important element in classifying marginality (Cotella, Vitale Bovarone, 2020). Moreover, in Italy's mountain areas there is a correlation between population loss, an increase in the number of elderly people, low income, and a general reduction in the supply of services (De Rossi, 2018). The positive relationship between *DWI* and *SEFI* in many municipalities in north-eastern Italy indicates a trade-off between lower environmental vulnerability and social demographic sustainability. In the central Apennines there is a positive environmental situation and a very worrying demographic situation. The mountains of southern Italy often present negative situations in terms of both environmental vulnerability and demographic weakness (Galderisi *et al.*, 2022).

These elements are linked to economic aspects: depopulation and economic decline are highly correlated with distance to essential services (Camarero, Oliva, 2019). Furthermore, the number of enterprises and the level of employment are linked to the vitality of the local production system and rural development (Urso *et al.*, 2019) and are useful for explaining the resilience of socio-economic systems in marginal areas (Faggian *et al.*, 2018). The peripherality of mountain areas is linked to limited accessibility to essential services through a vicious circle of self-reinforcement, which negatively affects vulnerability (Cerea, Marcantoni, 2016). The difficult accessibility, distance from the main centres that provide essential services, increasing state of abandonment and degradation of the built heritage, and prevalence of the agricultural sector over other productive sectors contribute to explain the poor performance in socio-economic indicators, as discussed by De Rossi (2018). This framework has contributed to increasing marginality and a marked deterioration of social conditions, particularly in the mountain areas of southern Italy (Storti *et al.*, 2020). These results seem to indicate a trade-off between the social and demographic fabric and environmental quality. While more intense land use might promote economic development, it might not be sufficient to prevent population loss and thus might have a negative impact on the provision of some ecosystem services (Vidal *et al.*, 2013).

5. CONCLUSIONS

We investigated the environmental state of Italian mountain areas based on a synthetic vulnerability index and identified the socioeconomic drivers of such vulnerability at the local level. Rural development, agricultural planning, and environmental policies should consider the spatial distribution of vulnerability across mountain areas. Management policies that are more attentive to the characteristics of mountain areas are needed. Moreover, the relationship between environmental vulnerability and socio-economic structures must be analysed in depth – at the local level – to guide rural development and spatial planning policies, thus contributing to a more integrative and sustainable management of mountain areas. These systems require more effective governance models to combine environmental risk management with human activities.

Some limitations of the study need to be mentioned. We chose variables and adopted a synthetic index to incorporate the multifactorial, interactive, and spatial dimensions that characterise vulnerability in mountain areas. However, this also represents a critical issue related to the possibility of applying the model to different territorial contexts and to the limited availability of data at the municipal level, particularly economic data. From a methodological point of view, some limitations may arise from the possible conservative behaviour of GWR parametric estimators, which can lead to a very low rejection rate of the null hypothesis of no effect for local model variables.

Future research efforts can be made at the local level to investigate the causes and related aspects for the most vulnerable municipalities and the relationship between environmental vulnerability and the socioeconomic drivers. This could involve qualitative analysis, including multidisciplinary analysis. This is relevant for cases where there is low environmental vulnerability and good demographic, social, and economic conditions, such as the Trentino Alto Adige region. However, it is also crucial for regions for which we identified environmental vulnerability: the Apennine area (i.e., Basilicata) and in the north-western Alpine area, such as Piedmont.

AUTHOR CONTRIBUTIONS

A.C.: Conceptualization, Investigation, Visualization, Writing – Original Draft, Writing – Review & Editing. G.C.: Supervision. L.M.: Conceptualization, Methodology, Investigation, Writing – Original Draft, Writing – Review & Editing. L.R.: Conceptualization, Methodology, Formal Analysis, Data Curation, Writing – Original Draft.

REFERENCES

Acampora A., La Faci A., Leporanico V., Potenzieri M., Potenzieri M. (2023). Italian inner areas: demographic characteristics, employment and commuting and territorialdifferentiations. *Rivista Italiana di Economia Demografia e Statistica*, LXXVII, 1.

Acreman M., Hughes K.A., Arthington A.H., Tickner D., Duenas M.A. (2020). Protected areas and freshwater biodiversity: a novel systematic review distils eight lessons for effective conservation. *Conservation Letters*, 13(1). DOI: https://doi.org/10.1111/conl.12684.

Aroca-Jiménez E., Bodoque J.M., García J.A. (2020). How to construct and validate an integrated socio-economic vulnerability index: implementation at regional scale in urban areas prone to flash flooding. *Science of Total Environment*, 746, 140905. DOI: https://doi.org/10.1016/j.scitotenv.2020.140905.

Bankoff G., Hilhorst D. (2022). *Why Vulnerability Still Matters: The Politics of Disaster Risk Creation*. Routledge, London.

Bernués A., Tenza-Peral A., Gómez-Baggethun E., Clemetsen M., Eik L.O., Martín-Collado D. (2022). Targeting best agricultural practices to enhance ecosystem services in European mountains. *Journal of Environmental Management*, 316, 115255. DOI: http://doi.org/10.1016/j.jenvman.2022.115255.

Bordi I., Fraedrich K., Petitta M., Sutera A. (2007). Extreme value analysis of wet and dry periods in Sicily. *Theoretical and Applied Climatology*, 87: 61-71. DOI: https://doi: 10.1007/s00704-005-0195-3.

Bretagnolle V., Benoît M., Bonnefond M., Breton V., Church J., Gaba S., Lamouroux N. (2019). Action-orientated research and framework: insights from the French long- term social-ecological research network. *Ecology and Society*, 24(3): 10. DOI: https://doi.org/10.5751/ES-10989-240310.

Brooks N., Sethi R. (1997). The Distribution of Pollution: Community Characteristics and Exposure to Air Toxics. *Journal of Environmental Economics and Management*, 32(2): 233-250. DOI: https://doi.org/10.1006/jeem.1996.0967.

Callisto M., Solar R., Silveira F.A.O., Saito V.S., Hughes R.M., Fernandes G.W., Gonçalves-Júnior J.F., Leitão R.P., Massara R.L., Macedo D.R., Neves F.S., Alves C.B.M. (2019). A Humboldtian approach to mountain conservation and freshwater ecosystem services. *Frontiers in Environmental Science*, 7. DOI: https://doi: 10.3389/fenvs.2019.00195.

Camarero L., Oliva J. (2019). Thinking in rural gap: mobility and social inequalities. *Palgrave Communications*, 5: 95. DOI: https://doi.org/10.1057/s41599-019-0306-x.

Carrer F., Walsh K., Mocci F. (2020) Ecology, economy, and upland landscapes: socio-ecological dynamics in the Alps during the transition to modernity. *Human Ecology*, 48: 69-84. DOI: https://doi.org/10.1007/s10745-020-00130-y.

Cerea G., Marcantoni M. (2016). *La montagna perduta. Come la pianura ha condizionato lo sviluppo italiano*. FrancoAngeli, Milan.

Chilla T., Heugel A., Streifeneder T., Ravazzoli E., Laner P., Tappeiner U., Egarter L., Dax T., Machold I., Pütz M., Marot N., Ruault J.F. (2018). Alps 2050 common spatial perspectives for the Alpine area. Towards a common vision. Final Report, ESPON Project Targeted Analysis, ESPON EGTC, Luxembourg.

Cong Z., Feng G., Chen Z. (2023). Disaster exposure and patterns of disaster preparedness: a multilevel social vulnerability and engagement perspective. *Journal of Environmental Management*, 339, 117798. DOI: https://doi.org/10.1016/j.jenvman.2023.117798.

Cotella G., Vitale Bovarone E. (2020). Improving rural accessibility: a multilayer approach. *Sustainability*, 12, 2876. DOI: https://doi.org/10.3390/su12072876.

Cutter S.L. (2021). The changing nature of hazard and disaster risk in the Anthropocene. *Annals of the American Association of Geographers*, 111(3): 819-827. DOI: https://doi.org/10.1080/24694452.2020.1744423.

Cutter S.L., Ash K.D., Emrich C.T. (2014). The geographies of community disaster resilience. *Global Environmental Change*, 29: 65-77. DOI: https://doi.org/10.1016/j.gloenvcha.2014.08.005.

Dasgupta P. (2021). *The Economics of Biodiversity: The Dasgupta Review*. HM Treasury, London.

Dax T., Schroll K., Machold I., Derszniak-Noirjean M., Schuh B., Gaupp-Berghausen M. (2021). Land abandonment in mountain areas of the EU: an inevitable side effect of farming modernization and neglected threat to sustainable land use. *Land*, 10: 591. DOI: https://doi.org/10.3390/land10060591.

De Rossi A. (eds) (2018). *Riabitare l'Italia. Le aree interne tra abbandoni e riconquiste*. Donzelli, Rome.

Di Giovanni G. (2016). Post-earthquake recovery in peripheral areas: The paradox of small municipalities'reconstruction process in Abruzzo (Italy). *Italian Journal of Planning Practice*, VI: 110-139.

Drakes O., Tates E. (2022). Social vulnerability in a multi-hazard context: a systematic review. *Environmental Research Letters,* 17, 033001. DOI: https://doi.org/10.1088/1748-9326/ac5140.

Eckstein D., Künzels V., Schäfers L. (2021). *Global Climate Risk Index 2021*. GermanWatch, Berlin.

Esposito G., Salvatis P., Bianchis C. (2023). Insights gained into geo-hydrological disaster management 25 years after the catastrophic landslides of 1998 in southern Italy. *International Journal of Disaster Risk Reduction*, 84, 103440. DOI: https://doi.org/10.1016/j.ijdrr.2022.103440.

European Commission (2021). *Overview of natural and man-made disaster risks the European Union may face: 2020 Edition*, Publications Office of the

European Union, Brussels. https://data.europa.eu/doi/10.2795/19072.

European Environment Agency (2020). *Healthy environment, healthy lives: how the environment influences health and well-being in Europe*, EEA Report n. 21/2019, Copenhagen.

Eurostat (2025). *Rural Europe*, European Commission, Luxembourg.

Faggian A., Gemmiti R., Jaquet T., Santini I. (2018). Regional economic resilience: the experience of the Italian local labor systems. *The Annals of Regional Science*, 60: 393-410. DOI: https://doi.org/10.1007/s00168-017-0822-9.

Ford J.D., Pearce T., McDowell G., Berrang-Ford L., Sayles J.S., Belfer E. (2018). Vulnerability and its discontents: the past, present, and future of climate change vulnerability research. *Climatic Change*, 151: 189-203. DOI: https://doi.org/10.1007/s10584-018-2304-1.

Fotheringham A.S., Brunsdon C., Charlton M. (2002). *Geographically Weighted Regression: The Analysis of Spatially Varying Relationships*. Wiley: New York.

Galderisi A., Bello G., Gaudio S. (2022). Le aree interne tra dinamiche di declino e potenzialità emergenti: criteri e metodi per future politiche di sviluppo. *Archivio di Studi Urbani e Regionali*, 133: 5-28.

Gariano S.L., Petrucci O., Rianna G., Santini M., Guzzetti F. (2018). Impacts of past and future land changes on landslides in southern Italy. *Regional Environmental Change*, 18: 437-449. DOI: https://doi.org/10.1007/s10113-017-1210-9.

Geldmann J., Barnes M., Coad L., Craigie I.D., Hockings M., Burgess N.D. (2013). Effectiveness of terrestrial protected areas in reducing habitat loss and population declines. *Biological Conservation*, 161: 230-238. DOI: https://doi.org/10.1016/j. biocon.2013.02.018.

Gobiet A., Kotlarski S. (2020). *Future climate change in the European Alps*. In Oxford Research Encyclopedia of Climate Science. Oxford University Press, Oxford. DOI: https://doi.org/10.1093/acrefore/9780190228620.013.767.

González-Leonardo M., Rowe F., Fresolone-Caparrós A. (2022). Rural revival? The rise in internal migration to rural areas during the COVID-19 pandemic. Who moved and Where? *Journal of Rural Studies*, 96: 332-342. DOI: https://doi.org/10.1016/j.jrurstud.2022.11.006.

IPCC (2023). *Climate Change 2023: Synthesis Report. Contribution of Working Groups I, II and III to the Sixth. Assessment Report of the Intergovernmental Panel on Climate Change*, Intergovernmental Panel on Climate Change, Geneva. DOI: https://doi.org/10.59327/IPCC/AR6-9789291691647.

Ispra (2018). *Territorio. Processi e trasformazioni in Italia*, Ispra Rapporti 296. Rome.

Ispra (2020). *Rapporto rifiuti urbani*, Ispra Rapporti 331. Rome.

Jha S.K., Negi A.K., Alatalo J.M., Negi R.S. (2021) Socio-ecological vulnerability and resilience of mountain communities residing in capital-constrained environments. *Mitigation and Adaptation Strategies for Global Change*, 26(8): 38. DOI: https://doi.org/10.1007/s11027-021-09974-1.

Karpouzoglou T., Dewulf A., Perez K., Gurung P., Regmi S., Isaeva A., Foggin M., Bastiaensen J., Van Hecken G., Zulkafli Z., Mao F., Clark J., Hannah D.M., Chapagain P.S., Buytaert W., Cieslik K. (2020). From present to future development pathways in fragile mountain landscapes. *Journal of Environmental Science and Policy*, 114: 606-613. DOI: https://doi.org/10.1016/j.envsci.2020.09.016.

Kokkoris I.P., Drakou E.G., Maes J., Dimopoulos P. (2018). Ecosystem services supply in protected mountains of Greece: setting the baseline for conservation management. *International Journal of Biodiversity Science, Ecosystem Services and Management*, 14: 45-59. DOI: https://doi.org/10.1080/21513732.2017.1415974.

Lenart-Boroń A.M., Boroń P.M., Prajsnar J.A., Guzik M.W., Żelazny M.S., Pufelska M.D., Chmiel M.J. (2021). COVID-19 lockdown shows how much natural mountain regions are affected by heavy tourism. *Science of Total Environment*, 806(3), 151355. DOI: https://doi.org/10.1016/j.scitotenv.2021.151355.

LeSage J.P. (2004). A family of geographically weighted regression models. In Anselin L., Florax R.J.G.M., Rey S.J. (eds) *Advances in Spatial Econometrics. Advances in Spatial Science* (pp. 241-264). Springer: Berlin, Heidelberg. DOI: https://doi.org/10.1007/978-3-662-05617-2_11.

Levers C., Schneider M., Prishchepov A.V., Estel S., Kuemmerle T. (2018). Spatial variation in determinants of agricultural land abandonment in Europe. *Science of Total Environment*, 644: 95-111. DOI: https://doi.org/10.1016/j.scitotenv.2018.06.326.

Lu B., Hu Y., Murakami D., Brunsdon C., Comber A., Charlton M., Harris P. (2022). High-performance solutions of geographically weighted regression. *Geospatial Information Science*, 25(4): 536-549. DOI: https://doi.org/10.1080/10095020.2022.2064244.

Marsden T. (2024). Contested ecological transitions in agri-food: emerging territorial systems in times of crisis and insecurity. *Italian Review of Agricultural Economics*, 79(3): 69-81. DOI: https://doi.org/10.36253/rea-15421.

Mastronardi L., Cavallo A., Romagnoli L. (2022). A novel composite environmental fragility index to analyse Italian ecoregions' vulnerability. *Land Use Policy*, 122, 106352. DOI: https://doi.org/10.1016/j.landusepol.2022.106352.

Mottet A., Ladet S., Coque N., Gibon A. (2006). Agricultural land-use change and its drivers in mountain landscapes: a case study in the Pyrenees. *Agriculture, Ecosystems and Environment*, 114: 296-310.

Murakami D., Tsutsumida N., Yoshida T., Nakaya T., Lu B. (2020). Scalable GWR: a linear-time algorithm for large-scale geographically weighted regression with polynomial kernels. *Annals of the American Association of Geographers*, 111(2): 459-480. DOI: https://doi.org/10.1080/24694452.2020.1774350.

OECD (2022). *States of Fragility 2022*. OECD Publishing, Paris. DOI: https://doi.org/10.1787/c7fedf5e-en.

Pagliacci F., Luciani C., Russo M., Esposito F., Habluetzel A. (2021). The socioeconomic impact of seismic events on animal breeding. A questionnaire-based survey from central Italy. *International Journal of Disaster Risk Reduction*, 56, 102124. DOI: https://doi.org/10.1016/j.ijdrr.2021.102124.

Pagliacci F., Russo M. (2019). Multi-hazard, exposure and vulnerability in Italian municipalities. In Borsekova K., Nijkamp P. (eds.) *Resilience and Urban Disasters* (pp. 175-198). Edward Elgar Publishing: Cheltenham. DOI: https://doi.org/10.4337/9781788970105.00017.

Pilone E., Demichela M. (2018). A semi-quantitative methodology to evaluate the main local territorial risks and their interactions. *Land Use Policy* 77: 143-154. DOI: https://doi.org/10.1016/j.landusepol.2018.05.027.

Pirasteh S., Fang Y., Mafi-Gholami D., Abulibdeh A., Nouri-Kamari A., Khonsari N. (2024). Enhancing vulnerability assessment through spatially explicit modeling of mountain social-ecological systems exposed to multiple environmental hazards. *Science of The Total Environment*, 930, 172744. DOI: https://doi.org/10.1016/j.scitotenv.2024.172744.

Romano B., Zullo F., Fiorini L., Marucci A. (2021). "The park effect"? an assessment test of the territorial impacts of Italian National Parks, thirty years after the framework legislation. *Land Use Policy*, 100, 104920. DOI: https://doi.org/10.1016/j.landusepol.2020.104920.

Rumpf S.B., Gravey M., Brönnimann O., Luoto M., Cianfrani C., Mariethoz G., Guisan A. (2022). From white to green: snow cover loss and increased vegetation productivity in the European Alps. *Science*, 376(6597): 1119-1122. DOI: https://doi.org/10.1126/science.abn6697.

Shepherd P.M., Dissart J.C. (2022). Reframing vulnerability and resilience to climate change through the lens of capability generation. *Ecological Economics*, 201, 107556. DOI: https://doi.org/10.1016/j.ecolecon.2022.107556.

Schmeller D.S., Urbach D., Bates K., Catalan J., Cogălniceanu D., Fisher M.C., Friesen J., Füreder L., Gaube V., Haver M., Jacobsen D., Le Roux G., Lin Y., Loyau A., Machate O., Mayer A., Palomo I., Plutzar C., Sentenac H., Sommaruga R., Tiberti R., Ripple W.J. (2022). Scientists' warning of threats to mountains. *Science of Total Environment*, 853, 158611. DOI: https://doi.org/10.1016/j.scitotenv.2022.158611.

Sena-Vittini M., Gomez-Valenzuela V., Ramirez K. (2023). Social perceptions and conservation in protected areas: Taking stock of the literature. *Land Use Policy*, 131, 106696. DOI: https://doi.org/10.1016/j.landusepol.2023.106696.

Stolton S., Dudley N., Avcıoğlu Çokçalışkan B., Hunter D., Ivanić K.-Z., Kanga E., Kettunen M., Kumagai Y., Maxted N., Senior J., Wong M., Keenleyside K., Mulrooney D., Waithaka J. (2015). Values and benefits of protected areas. In Worboys G.L., Lockwood M., Kothari A., Feary S., Pulsford I. (eds) *Protected Area Governance and Management* (pp. 145-166). ANU Press, Canberra.

Storti D., Provenzano V., Arzeni A., Ascani M., Silvia Rota F. (2020). *Sostenibilità e innovazione delle filiere agricole nelle aree interne. Scenari, politiche e strategie*. FrancoAngeli, Milan.

Stotten R., Ambrosi L., Tasser E., Leitinger G. (2021). Social-ecological resilience in remote mountain communities: toward a novel framework for an interdisciplinary investigation. *Ecology and Society*, 26(3): 29. DOI: https://doi.org/10.5751/ES-12580-260329.

Sun Y., Li Y., Ma R., Gao C., Wu Y. (2022). Mapping urban socio-economic vulnerability related to heat risk: a grid-based assessment framework by combing the geospatial big data. *Urban Climate*, 43, 101169. DOI: https://doi.org/10.1016/j.uclim.2022.101169.

Teare R. (2021). Reflections on the theme issue outcomes: Tourism sustainability in natural, residential and mountain locations: what are the current issues and questions? *Worldwide Hospitality and Tourism Themes*, 12(4): I-VI. DOI: https://doi.org/10.1108/WHATT-05–20200036.

Thorn J.P.R., Klein J.A., Steger C., Hopping K.A., Capitani C., Tucker C.M., Nolin A.W., Reid R.S., Seidl R., Chitale V.S., Marchant R. (2020). A systematic review of participatory scenario planning to envision mountain social-ecological systems futures. *Ecology and Society*, 25(3): 6. DOI: https://doi.org/10.5751/ES-11608-250306.

Tobler W.R. (1970). A computer movie simulating urban growth in the Detroit region. *Economic Geography*, 46: 234-240. DOI: https://doi.org/10.2307/143141.

Trigila A., Iadanza C. (2018). *Landslides and floods in Italy: hazard and risk indicators* - Summary Report, 267, Institute for Environmental Protection and Research (ISPRA). DOI: https://doi.org/10.13140/RG.2.2.14114.48328.

Uncem (2025). *Rapporto Montagne Italia 2025. Istituzioni Movimenti Innovazioni. Le Green Community e le sfide dei territori*, Rubettino, Soveria Mannelli.

UNDRO (1979). *Natural Disasters and Vulnerability Analysis. Report of Expert Group Meeting*, United Nations, Geneva.

UNISDR (2015). *Sendai Framework for Disaster Risk Reduction, 2015-2030*, United Nations, Geneva.

Urso G., Modica M., Faggian A. (2019). Resilience and sectoral composition change of Italian inner areas in response to the great recession. *Sustainability*, 11, 3432. DOI: https://doi.org/10.3390/su11123432.

Uval (2014). *A strategy for inner areas in Italy: definition, objectives, tools and governance*. Materiali Uval Series, Rome. http://www.dps.gov.it/it/pubblicazioni_dps/materiali_uval

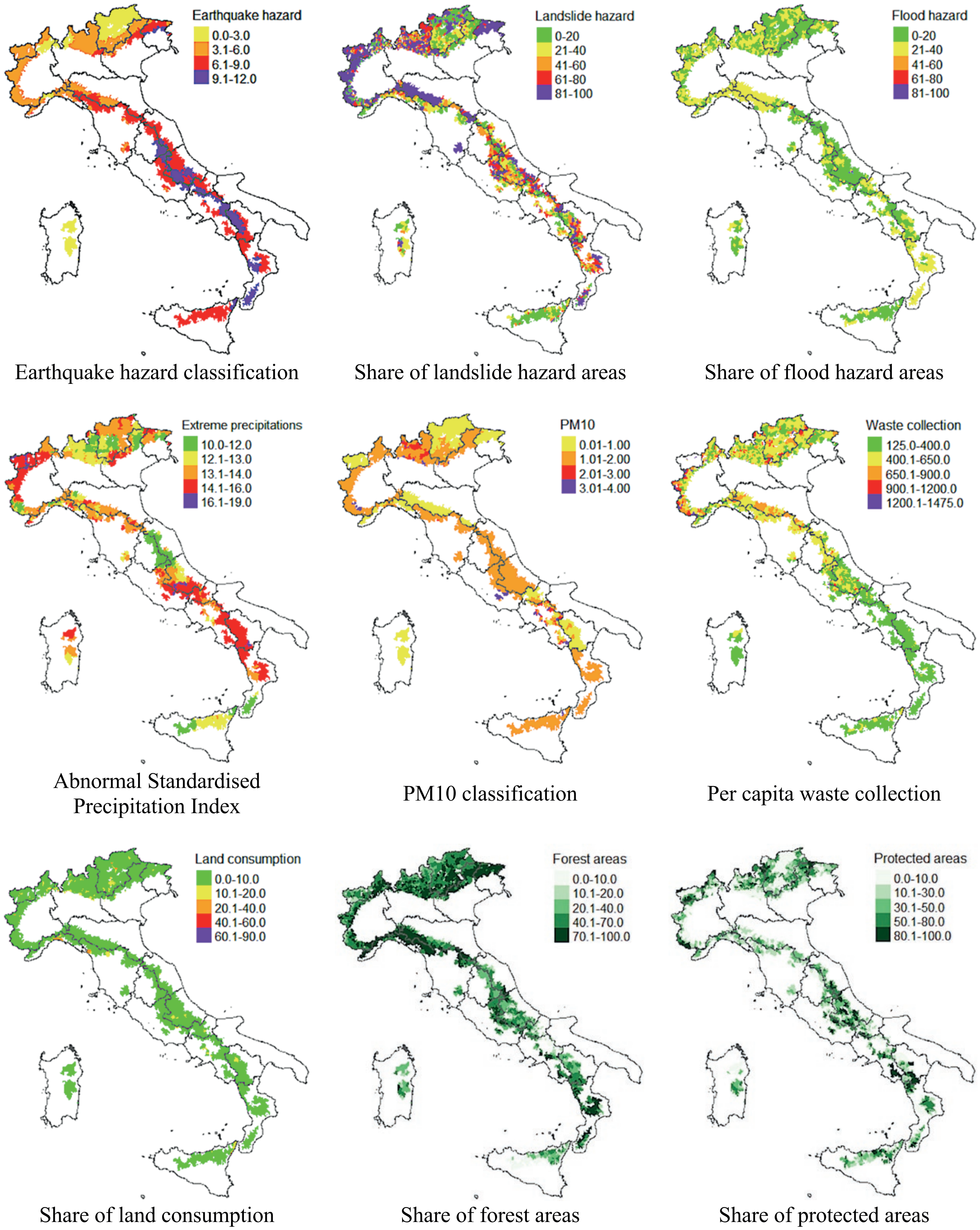
Vendemmia B., Lanza G. (2022). Redefining marginality on Italian Apennines: An approach to reconsider the notion of basic needs in low density territories, *Region*, 9(2): 131-148. DOI: https://doi.org/10.18335/region.v9i2.430.

Vidal B., Martínez-Fernández J., Sánchez-Picón A., Pugnaire F. (2013). Trade-offs between maintenance of ecosystem services and socio-economic development in rural mountainous communities in southern Spain: A dynamic simulation approach. *Journal of environmental management*, 131. DOI: https://doi.org/10.1016/j.jenvman.2013.09.036.

Whitaker S.H. (2023). "The forests are dirty": effects of climate and social change on landscape and well-being in the Italian Alps. *Emotion, Space and Society*, 49, 100973. DOI: https://doi.org/10.1016/j.emospa.2023.100973.

APPENDIX

Figure A.1. Geographical distribution of the original environmental indicators in Italian mountain areas.



Source: the data are compiled from INGV, ISPRA, CRU-UEA, CLC, UN-WCMC, and Istat.

REA | ITALIAN REVIEW OF AGRICULTURAL ECONOMICS

Firenze University Press
www.fupress.com/rea

Short communication

Policies for the Agricultural Knowledge and Innovation System in southern Italian areas: the state of the art

Anna Vagnozzi, Francesca Giarè*

CREA – Research Centre for Agricultural Policies and Bioeconomy, Italy
*Corresponding author. E-mail: francesca.giare@crea.gov.it

OPEN ACCESS

Citation: Vagnozzi, A., & Giarè, F. (2025). Policies for the Agricultural Knowledge and Innovation System in southern Italian areas: the state of the art. *Italian Review of Agricultural Economics* 80(3): 77-86. DOI: 10.36253/rea-16865

Received: November 14, 2025

Revised: December 15, 2025

Accepted: December 16, 2025

Data Availability Statement: Data will be made available by the corresponding author upon request.

Competing Interests: The Author(s) declare(s) no conflict of interest.

Guest Editor: Francesco Mantino

ORCID
AV: 0000-0003-4988-9157
FG: 0000-0001-9541-908X

Abstract. This paper analyses the state of innovation in Italian agriculture, with a particular focus on southern areas, and examines the evolution of European Agricultural Knowledge and Innovation System (AKIS) policies over the last 15 years. Using data from the Italian National Institute of Statistics (ISTAT) Agricultural Census and Farm Accountancy Data Network (FADN)-derived indicators, this study highlights a markedly low propensity for innovation among farms in southern Italy, linked to structural weaknesses; limited digitalisation; and suboptimal performance across economic, environmental, and social dimensions. Despite these challenges, regional policy strategies appear largely uniform throughout Italy, showing little adaptation to the specific needs of lagging areas. The review of rural development interventions illustrates persistent difficulties in implementing advisory services, contrasted with stronger uptake and better financial performance of innovation-oriented measures, particularly Operational Groups under the European Innovation Partnership for Agricultural Productivity and Sustainability. The Italian Common Agricultural Policy Strategic Plan for 2023-2027 introduces mechanisms to strengthen system coordination and enhance advisory and knowledge-exchange functions; however, budget allocations remain modest, especially in southern Italy. In conclusion, fragmentation within the Italian AKIS, coupled with cautious regional programming, risks perpetuating existing disparities and limiting the agricultural sector's capacity to address structural, environmental, and competitiveness challenges.

Keywords: AKIS, agricultural policy, agricultural innovation, interactive approach.
JEL codes: Q16, Q18.

HIGHLIGHTS

- Agriculture in southern Italy presents critical areas – from competitiveness to sustainability – but few farmers invest in innovation.
- The EU rural development policies have promoted a strategic process to support farms and agricultural areas to invest in innovation and knowledge.
- The European Commission proposed new methods and approaches highlighting the importance of networks, interactivity, co-innovation, and AKIS implementation.

– After 15-20 years, the time is right to analyse the process to assess how the funds have been invested and the effectiveness of interventions.

1. INTRODUCTION

Innovation is studied from different perspectives and according to different disciplines, resulting in a multitude of definitions. We adopt the definition from the Organisation for Economic Co-ordination and Development (OECD): "an innovation is a new or improved product or process (or combination thereof) that differs significantly from the unit's previous products or processes and that has been made available to potential users (product) or brought into use by the unit (process)" (OECD/Eurostat 2018). In recent years, much research has focused on identifying the factors that influence the development and adoption of local innovations. These include social and economic resources, institutional characteristics, and the interactions between a territory and its environment (Capello, Lenzi, 2019), as well as geographical, economic, and technological proximity (Bruno *et al.*, 2025).

Although our focus is on innovation in agriculture, it is crucial to consider the results of the regional approach to innovation. The agricultural sector faces complex challenges caused by climate change, economic difficulties, and geopolitical instability. Innovative solutions that farms can adopt, including sustainable practices and technological breakthroughs, can help address them, making farmers more resilient and territories more competitive. Indeed, innovation is viewed as one of the main factors that can effectively address the challenges facing the agricultural system (Oliveira *et al.*, 2019), from climate change and biodiversity loss to geopolitical instability (FAO, 2024). Hence, it can accelerate the transition to sustainable agricultural models (Masi *et al.*, 2022). This ability, when closely linked to information and knowledge dissemination processes, as well as learning and social interaction, is recognised at the European level (EU SCAR AKIS, 2019). Furthermore, the OECD (2019) focuses on the positive impact of innovation on productivity, competitiveness, profitability, and even sustainability of the sector.

This attention has manifested in various ways over the years. The European Union (EU) formally recognised the strategic role of knowledge and innovation in its development agenda with the adoption of the Europe 2020 strategy. This vision places human capital and research at the heart of efforts to transform Europe into the world's leading knowledge-based economy. In the agricultural sector, this direction began to take shape during the EU policies formulated during the 2007-2013 programming period and was further consolidated through the 2014-2020 initiatives, notably Horizon 2020 and the Rural Development Programmes.

In the early phase (2007-2013), the focus was primarily on enhancing competitiveness through training, information, and advisory interventions. Innovative efforts were limited to small-scale trials with minimal stakeholder involvement. The subsequent programming period (2014-2022) marked a significant shift. Knowledge and innovation were recognised as cross-cutting priorities, and the European Innovation Partnership for Agricultural Productivity and Sustainability (EIP-AGRI) was introduced (European Commission, 2012). This initiative promoted a collaborative model in which farmers, researchers, and facilitators worked together to address real-world challenges. The Agricultural Knowledge and Innovation System (AKIS) emerged as the central framework for coordinating these efforts.

AKIS is a collaborative network of organisations, enterprises, and individuals, including institutions and policies that influence how different actors interact, share, access, exchange, and utilise knowledge (Kassem *et al.*, 2022; Zahran *et al.*, 2020). It has strong potential to enhance the economic performance of farming and contribute to agricultural sustainability because it may increase synergies and complementarity among actors. AKIS is both an analytic construction aimed at describing organisations and actors revolving around innovation and knowledge, including their functions and relationships, and a European strategy aimed at reinforcing the agricultural system through specific actions based on the interaction model. According to the constructivist paradigm, innovation is the product of social phenomena that occur through complex interactions between different actors. This approach implies that a heterogeneous group of actors cooperates to identify, develop, and introduce innovative solutions, as demonstrated by research and/or development activities about the knowledge and innovation process of recent decades. It focuses on the need to connect science and practice effectively and to boost knowledge exchange and innovation for the benefit of farmers (EU SCAR, 2012, 2015; EU SCAR AKIS, 2019). It especially emphasises the necessity to recognise the coexistence of innovation resulting from research and that from practice, having equal dignity in the innovation process (Ingram *et al.*, 2017).

However, the AKIS situation at the European level is diverse and multi-faceted. Each country organised the previous systems differently (EU SCAR, 2012) and has unique institutional, legislative, and cultural contexts

(Knierim *et al.*, 2015). Consequently, implementation of Common Agricultural Policy (CAP) measures varies widely across EU Member States, only reaching around 10% of EU farms and 20% of CAP beneficiaries (European Commission, 2021).

Introduction of the EIP-AGRI was the main innovation in the 2014-2022 CAP programming period, aimed at overcoming the so-called linear model of innovation diffusion and introducing a new strategy based on the characteristics described above (Mikolič, Slavič, 2025). This instrument received positive feedback in Europe, mainly under the CAP interventions, with more than 3,800 Operational Groups (OGs) funded, compared with the 3,200 initially planned. A study commissioned by the Directorate-General of Agriculture and Rural Development (DG AGRI) highlighted, among other things, the ability of OGs to test and introduce innovative solutions on farms, to disseminate the adopted solutions beyond their partners, and the emergence of new forms of collaboration between partners (European Commission, 2024). Nevertheless, the growing importance of these strategies and tools has not been followed by increased expenditure, which remained marginal within the overall CAP budget for the 2014-2020 period (Labarthe, Beck, 2022).

Because AKIS relies on the active interaction of many different actors, initiatives that strengthen connections between organisations and policies can help close the gap between research- and practice-driven innovation, while directly involving farmers in shared knowledge and innovation processes. Indeed, the success of AKIS depends on the ability to effectively coordinate among various stakeholders, to disseminate agricultural knowledge, and to respond to farmers' needs, as well as the availability of effective agricultural advisory services. Therefore, many factors can foster the introduction and effective adoption of innovations. The relationships among different actors involved in identifying problems and finding innovative solutions as well as the institutional and policy context are crucial. Many countries have a fragmented or ineffective AKIS (Kountios *et al.*, 2024), depending on the choices made by regional or national administrations, as well as from the variety of actors and their relationships. According to Birke *et al.* (2025), "the effective functioning of AKIS relies not only on the presence of multiple actors, but also on mechanisms that allow their interaction at different levels and sectors", with policy-based (top-down) coordination mechanisms and network-based mechanisms within national AKIS.

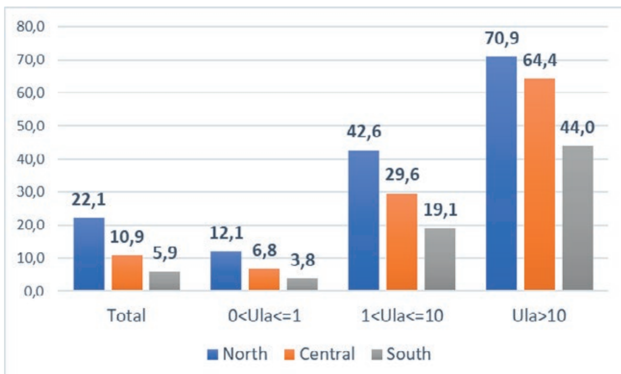
This article examines the level of innovation among farms using data from the Agricultural Census and the Farm Accountancy Data Network (FADN), as well as the implementation of related policies in Italy, particularly the southern regions. We aim to suggest possible lines of research to understand if there are specific approaches that are adequate to meet the needs and problems farmers face. What weaknesses can still be found? In which areas? While we are aware of the difficulties of conducting a comprehensive study, due to the scarcity of data and the complexity of the issue, we provide some food for thought on the challenges facing the Italian agricultural system.

2. INNOVATION IN ITALIAN AGRICULTURE: SPECIFICITIES AND CHALLENGES

According to the last Agricultural Census in Italy, around 125,000 farms introduced one or more innovations[1] from 2018 to 2020. They represented 11% of the total number of farms surveyed, with great variability among regions/autonomous provinces. The southern regions showing the lowest percentage (5.9%) (Figure 1).

The data support common observations about innovative farms. Innovation is more common on larger farms, measured by the number of work units, and on farms managed by younger farmers (Figures 1 and 2). However, the presence of innovative farms is lower in southern Italy, even when considering farm size and farmer age.

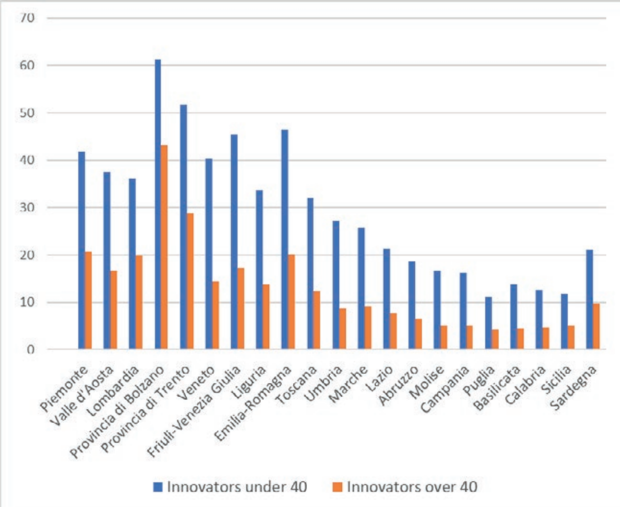
Figure 1. Innovative farms by group of regions and agricultural work unit (% of total farms).



Source: ISTAT Agricultural Census, 2020.

[1] According to the explanatory notes of the Agricultural Census, the question on innovation asks whether, in the three-year period of 2018-2020, the holding made investments aimed at innovating production techniques or management (e.g., precision agriculture, research and development, etc.). If the answer is yes, then the respondents are asked to specify the stages or areas concerned, such as varieties, breeds, clones, etc.

Figure 2. Comparison between innovators over 40 and under 40 years of age by region (% of total farms).



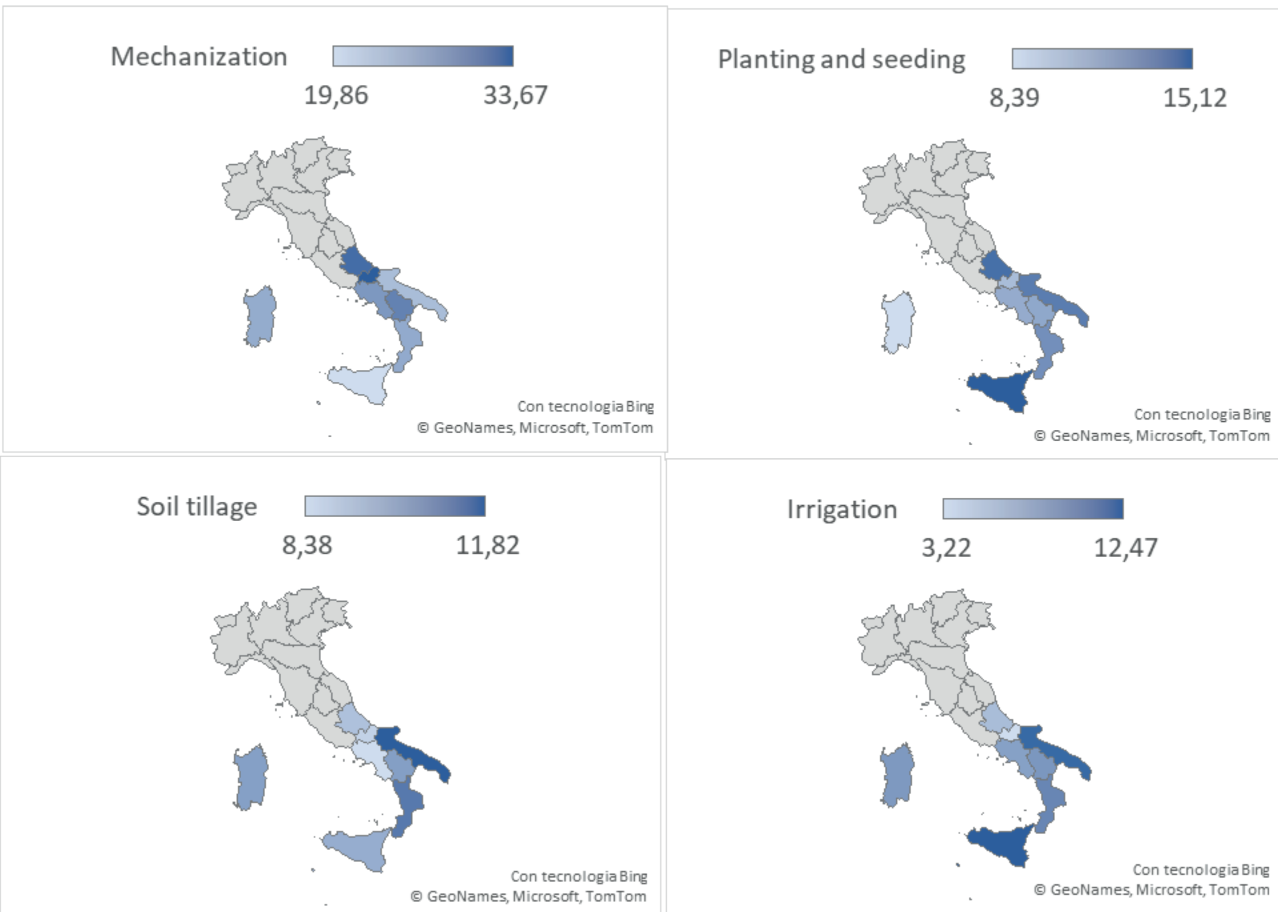
Source: ISTAT Agricultural Census, 2020.

Mechanisation is the production process with the highest level of innovative investments, both nationally (28%) and by region (29% for northern, 31% for central, and 24% for southern). However, in the Southern Italy, this percentage is slightly lower, while innovation in planting and seeding (12%), soil tillage (10%), and irrigation (9%) is relatively more significant. The analysis of investment choices among southern regions shows a heterogenous situation (Figure 3).

Finally, the digitisation of Italian farms has outperformed other innovative processes, as 16% of farms have adopted it. There is great variation between the regions, especially northern (33.1%) and southern (7.7%) Italy. Traditional applications, such as accounting, are still widely used in production processes, both in the field and in the stable (Figure 4).

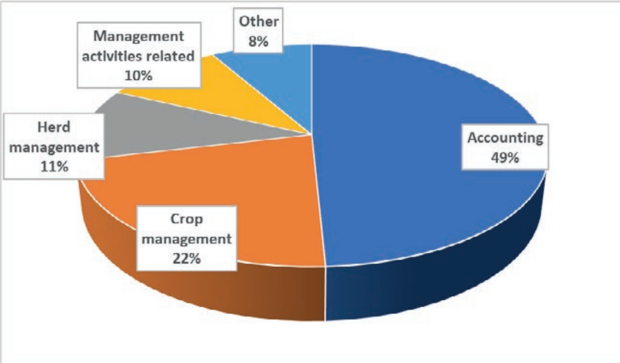
The FADN survey does not collect specific data about the adoption of innovative practices by farms. However, a methodology was developed to derive the

Figure 3. Innovative investments in southern Italian regions by productive process steps (% of total farms).



Source: ISTAT Agricultural Census, 2020.

Figure 4. Use of digitalisation on farms (% of total farms).



Source: ISTAT Agricultural Census, 2020.

innovation needs of farms, albeit indirectly, from a set of socio-economic and technical indicators calculated based on FADN variables (Arzeni *et al*., 2021; Bonfiglio, 2024). The approach is based on the idea that some aspects of farm performance are influenced by whether specific innovations have been adopted. To apply this method, we grouped farms into homogeneous clusters within each Italian region. We compared the performance of these clusters (measured through the indicators) to the average performance of similar clusters in the Italian macro-regions (North-west, North-east, Centre, South, and Islands). If a region's indicator was below the district average, then we interpreted this as a potential need for innovation in that region.

The results of this analysis should be interpreted as potential signs of a lack of innovation because it is an indirect survey and suboptimal performance may also be stem from other internal and external factors that affect the farm. Analysis of the FADN data from 2018 to 2023 shows major economic, environmental, and social difficulties for southern Italy. Economic indicators suggest that innovations could help reduce variable costs and increase productivity. Numerous innovative solutions can also be adopted to address environmental impacts, including a reduction in the use of pesticides and more efficient use of energy and water resources. However, innovations have less direct effects on the social impacts, although improved economic efficiency has a positive impact on job stability and perhaps also on farmers' interest in increasing their knowledge base.

The above analysis of FADN data provides points for consideration, particularly when examined in greater depth by farm size and production sector, as Arzeni *et al*. (2021) and Bonfiglio (2024) showed. Here, the key takeaway is that rural areas in southern Italy show a low propensity for innovation, which may contribute to some of the sustainability issues faced by its farms. In this context, promotion policies play a crucial role.

3. EVOLUTION OF AKIS POLICIES IN ITALY

Over the last 15 years, knowledge and innovation policies have been implemented relatively uniformly throughout Italy. There has been no difference in governance and management between northern, central, and southern Italy: all regions have established discussion and support networks to proceed in a relatively homogenous manner.

European policies aimed at promoting AKIS have focused on certain areas of action, especially training, coaching, information, knowledge transfer, study visits, advisory services, testing, and dissemination of innovation. As a rule, funding is distributed to those who provide these services, and the farms and rural areas uses these services. Across the various programming periods, the names of the action areas, their specific focus, and their implementation methods have changed. Thus, we compared AKIS policy interventions by grouping the actions into training/information, advisory services, and innovation. The first area concerns measures aimed at increasing the human capital of farms. The second area involves technical/economic and organisational support to manage production processes. Finally, the third area concerns the dissemination and adoption of innovations useful for solving business and territorial problems.

An analysis of the content of rural development interventions in Italy shows that training and information measures have consistently played a significant role, one that has rarely been questioned, and their financial implementation has been not very complex. Each region has financed them by targeting region-specific topics of interest to agriculture and rural areas. A critical element is the implementation methods, which are usually very conventional: traditional in-person training, characterised by unidirectional transfer of knowledge, or information disseminated in the press or via institutional web channels. Moreover, these measures are usually delivered in a very rigid manner, so they cannot respond to urgent needs that may arise. Furthermore, not all potential users can benefit from these measures due to educational pre-requisites and a lack of ability to use new communication tools (Rete Rurale Nazionale, 2020).

From a financial perspective (CREA, 2017; Rete Rurale Nazionale, 2023b), training and information measures present challenges typical of intangible intervention, particularly in ensuring stable and continuous spending throughout the implementation of European programmes. As a result, expenditure is concentrated towards the end of the programming periods and is often lower than what had been planned. Indeed, actual spending on training/information interventions was 24% lower in 2007-2013 and 11% lower in 2014-2022 compared with planned spending.

Advisory services, by contrast, have followed a much more difficult path. During the 2007-2013 programming period, they focused on only a few topics (mainly related to conditionality) and had a narrow objective (economic competitiveness), generating little interest among both users and advisory providers. In addition, implementation was constrained by low funding based on advisory activity, the need for accreditation, and binding administrative rules. During the 2014-2022 programming period, the scope of counselling was broadened to cover all needs while providing a minimum scope of intervention that each region had to cover. However, at an early stage, the implementation procedures for the disbursement of funds involved tenders that were complex and expensive due to the need to consider the additional expense of VAT. For the most part, the regional institutions refrained from initiating these procedures and worked together with the Ministry of Agriculture to get the European Commission to change them. This endeavour led to changes in administrative procedures, but the start of the intervention was delayed. As a result, advisory services saw a significant reduction in the initially allocated funds: 71% and 51% for the 2007-2013 and 2014-2022 programming periods, respectively.

The promotion of innovation had markedly different results (CREA, 2017; Rete Rurale Nazionale, 2023b). For the 2007-2013 programming period, this area received little initial funding, and it primarily aimed to test innovations that required territorial and/or climatic-pedological verification before wider dissemination. However, interest from research and development organisation led to a 17% increase in the budget originally allocated at the start of the programming period. During the 2014-2022 programming period, the promotion of innovation shifted towards the EIP-AGRI approach. Due to its methodological complexity, it required a strong commitment for its promotion and facilitation. This first occurred at the European level with a dedicated support network and then at the national and regional levels, supported by the National Rural Network and local agencies. In addition, the strong demand for innovative solutions to the technical, economic, management, environmental, and climatic problems faced attracted the interest of numerous research, service, and dissemination organisations. They often formed complex and effective partnerships with enterprises. Financial investment in this area also increased: it was 29% higher compared to what was budgeted for the 2007-2013 programming period.

In particular, Measures 16.1 and 16.2, relating to OGs, absorbed the majority of regional resources and interest. With 893 projects (compared to the 626 initially planned), Italy has the higher number of OGs among EU Member States. An analysis of the results of the EIP-AGRI in Italy, conducted in 2021-2022, highlighted how OGs experience enabled partners to establish professional relationships and collaborations, enhance their expertise, and involve a large number of businesses, contributing to the growth of not only individual partners but the entire system (Arzeni *et al*., 2023). The number of OGs varies significantly across regions. Emilia-Romagna funded 265 projects, spending almost 70 million, followed by Sicily with 74 projects and almost 36 million euros. The number of approved projects and financial resources are closely linked to the political strategies and implementation and procedural choices of the individual regional Managing Authorities.

Expenditure data of the Rural Development Programme measures directly linked to AKIS was nearly 541 million euros, roughly half of which was in northern Italy. There were notable regional differences in terms of the allocated resources and types of interventions funded. While Measure 16.1, which financed OGs, was generally successful, Measure 16.2, supporting advisory services, faced significant difficulties. Performance was stronger in northern Italy, mainly due to the excellent results for Veneto, with over 12 million euros, approximately half of the total expenditure in this region. In central Italy, Toscana performed very well, with over 11 million euros, also representing more than half of the expenditure. In southern Italy, there were minimal regional differences, with total expenditure representing just 0.16% of the total Rural Development Programme (Table 1). Overall, the share of AKIS-related measures in the Rural Development Programme is very low: only 2.7% of total spending is in this area, and in southern Italy it barely exceeds 1.5%.

Evaluating the impact of these activities, both in terms of knowledge and innovations introduced as well as networks of relationships, is quite challenging. This difficulty is compounded by the lack of data on the number of farms reached by the initiatives and the lack of information on their structure, problems, and needs, and economic situation before and after the interventions. Given the complexity of these initiatives, there has been limited research on the results and impacts of EIP-AGRI (Giarè, Vagnozzi, 2021; Proietti, Cristiano, 2023).

Table 1. Total public expenditure for Agricultural Knowledge and Innovation System (AKIS) measures in the 2007-2013 programming period.

	Italy (euros)	Italy (%)	North (%)	Centre (%)	South (%)
Measure 1 – Training and Information	121,692,525	*22.5*	*31.0*	*21.0*	*16.0*
Measure 2 – Advisory	46,953,251	*8.7*	*10.0*	*14.0*	*10.0*
Measure 16.1 – EIP-AGRI	193,540,139	*35.8*	*37.0*	*23.0*	*38.0*
Measure 16.2 – Cooperation for innovation	179,072,550	*33.1*	*22.0*	*42.0*	*36.0*
Total	541,258,466	*100*	*100*	*100*	*100*
AKIS measure over Rural Development Programme total expenditure (%)	2.7		*3.8*	*3.6*	*1.5*

Note: separate data are not available Measures 16.1 and 16.2 as the official monitoring reports the data for the entire Measure 16. Therefore, data relating to the allocated resources are used.
Source: NRN 2024 quarterly report.

Regarding OGs, it is important to remember that knowledge sharing and innovation processes do not always lead to the adoption of innovations. Innovation is best understood as an interactive process, characterised by dynamic exchanges among different actors, which can facilitate the adoption and dissemination of innovative practices (Knierim *et al*., 2015). OGs provide a setting where farmers play an important role in identifying problems and introducing innovations (Kok, Klerkx, 2023). However, based on an analysis of the qualitative information provided by innovarurale.it, southern Italy has received a significant share of funding under the CAP, but its innovation remains limited. Southern OGs show lower levels of innovation than north-eastern OGs, highlighting regional disparities (del Puente *et al*., 2024). There are also differences in the type of innovations introduced by OGs. For example, in Campania, activities focus more on diversification in terms of themes and dissemination of materials (66.7%). In Puglia, activities focus on service innovations (70.8%) and logistics systems (22.9%). Sicily had a strong propensity for new goods (72.1%) and design/packaging (13.1%) (del Puente *et al*., 2025).

3.1. AKIS programming for 2023-2027

Regulation (EU) 2021/2115 places knowledge and innovation at the service of all CAP objectives for the 2023-2027 period, identifying nine specific goals for the development of the agri-food and forestry sectors and assigning to a cross-cutting role the objective focused on modernisation. This includes promoting knowledge exchange, innovation, and digitalisation, and ensuring farmers have better access to research, training, and advisory services (Art. 6, par. 2). The European Commission has emphasised the importance on ensuring AKIS functions in a coordinated and interconnected manner, with advisory services playing a central role in disseminating knowledge and linking system components (Di Santo *et al*., 2025). Innovation and digitalisation are seen as key drivers for the modernisation of the agriculture and agri-food sectors, mainly when there are interactions among multiple actors. The more intense interactions within AKIS, the greater its capacity to promote development (European Commission, 2023). To operationalise their goals, CAP regulation provides two main instruments: Cooperation (Art. 77) and Knowledge Exchange and Information (Art. 78). The Italian CAP Strategic Plan for 2023-2027 represents a national commitment to fostering a more integrated, innovative, and knowledge-driven agricultural system (Table 2).

For the 2023-2027 programming period (Rete Rurale Nazionale 2023a), Italy has allocated over 451 million euros to AKIS-related interventions, approximately 2.8% of the total public budget for rural development. This represents a slightly higher share compared with the previous programming period. When broken down by thematic area, innovation (SRG01-08-09) has received the largest share of funding (49.8%), followed by training and information (22.6%) and advisory services (17.8%). These allocations reflect the cautious financial approach of the Italian regions, shaped by past implementation experiences.

Although Regulation (EU) 2021/2115 places particular emphasis on strengthening advisory services – given their underperformance in previous cycles – regional investment in this area remains limited. This cautious stance is also evident in the overall AKIS budget, suggesting a conservative interpretation of the regulation's ambitions. Nonetheless, the Italian CAP Strategic Plan introduces several innovative elements, including support for innovation facilitation, demonstration activities, and the integration of specialised technical assistance for advisors (back office). However, these measures

Table 2. Agricultural Knowledge and Innovation System (AKIS) interventions for the Italian Common Agricultural Policy Strategic Plan for 2023-2027.

Interventions	Number of regions	Total amount (euros)	% Italy	% North	% Centre	% South
SRG01 – Support to PEI AGRI Operational Groups	18	164,699,086	*36.5*	*32*	*35.3*	*42.2*
SRG08 – Support for pilot and innovation testing actions	10	38,850,000	*8.6*	*11*	*12.5*	*4.3*
SRG09 – Cooperation for innovation support actions and services aimed at the agricultural, forestry, and agri-food sectors	10	21,223,310	*4.7*	*2.5*	*1.5*	*8.8*
SRH01 – Provision of advisory services	18	80,096,534	*17.8*	*20.5*	*19.8*	*13.4*
SRH02 – Advisory training	12	7,222,074	*1.6*	*2.0*	*1.1*	*1.4*
SRH03 – Training of farmers, workers in agriculture, livestock, and food industries, and other private and public entities instrumental to the development of rural areas	19	67,415,347	*14.9*	*19.2*	*13.7*	*10.7*
SRH04 – Information campaigns	16	27,315,148	*6.1*	*3.5*	*10.7*	*6.6*
SRH05 – Demonstration campaigns for agriculture, forestry, and rural areas	12	16,141,126	*3.6*	*4.8*	*1.7*	*3.1*
SRH06 – Back-office services for the AKIS	12	28,179,247	*6.2*	*4.5*	*3.7*	*9.5*
Total amount		451,141,872	*100.0*	*100.0*	*100.0*	*100.0*
Percentage on total Rural Development Programme expenditure		*2.8*		*4.4*	*3.9*	*2.7*

Source: our elaboration based on CAP Network data.

have not been adopted uniformly across all regions and, along with advisor training, received limited financial allocations. These differences reflect the varying ways in which each region organises and manages its AKIS, as well as by problems and challenges they face. Overall, AKIS interventions account for less than 3.5% of the total financial allocation ranging from 2.7% in southern Italy to 4.4% in northern Italy (Table 2). An analysis of regional choices within the regions reveals that this trend is similar to that of the previous programming: the share of interventions for innovation is the highest (45%, 49%, and 55% for northern, central, and southern Italy, respectively), followed by training/information (32%, 30%, and 30%, respectively), and advisory services (23%, 21%, and 15%, respectively). Note that the concentration of funds on innovation is greater in southern Italy, where just over a tenth of the total amount is invested in advisory services.

The programming data indicate a general continuity in policy implementation at the regional level, both in terms of the type of intervention and the budget allocated, except for minor differences. The share of funding allocated to training/information is more balanced among the three regions, perhaps because some interventions are managed by public bodies (departments or their agencies) that have long needed new roles and related financial resources. To address the fragmentation and limitations of the Italian AKIS, the Italian CAP Strategic Plan introduced the AKIS Coordination Body. It is designed to facilitate communication among the different actors and improve the system at the national and regional levels (Sutherland, Prager 2025).

4. CONCLUSION

Our descriptive analysis indicates that farms in southern Italy experience greater difficulties in adopting innovations compared with those in northern and central Italy. These difficulties span multiple dimensions, from competitiveness to sustainability. Despite these issues, regional policy choices appear rather uniform, with little differentiation in response to local criticalities. Such cautious regional approaches to innovation policy risks depriving farms of adequate and widespread support across the territory, potentially undermining the strong investment in innovation. This could limit the ability to address structural challenges of the agricultural sector such as human capital development and the adoption of new technologies. In addition, the overall effectiveness of rural development policy could be reduced, as knowledge transfer and advisory services are essential enablers of competitiveness, sustainability, and social inclusion. Uniform policies also risk perpetuating existing disparities, both between agriculture and other economic sectors, and within the agricultural sector itself, particularly between small- and medium-sized enterprises and more advanced actors.

AKIS presents an opportunity to support farmers and other actors in addressing challenges related to competitiveness and the transition towards a more environmentally and socially sustainable and equitable system. AKIS functions as an analytic framework to understand organisations and actors involved in innovation and a European strategy to strengthen the agricultural system through specific actions. Thus, it provides a useful lens to study dynamics at the local and regional levels. Our analysis of the Italian regions – albeit partial due to the lack of data – reveals fragmented innovation, information/training, and advisory interventions in the 2023-2027 CAP programming period, inconsistent with the logic of the AKIS. The creation of regional and national coordination bodies could help overcome this limitation. Additional measures (i.e., local innovation hubs, targeted training for trainers and advisors, and stronger integration of AKIS interventions with other policies) could enhance Italy's AKIS, thereby improving the sector's performance and supporting policy implementation.

Our study has some limitations, including the inability to answer all the questions posed in Section 1. Nevertheless, it provides a starting point for discussion and highlights the need for more comprehensive research on policy effects. In this context, it is desirable that the European Commission supports a series of funded research projects on these topics. Effective implementation of these studies will require robust datasets that can support continuous and detailed analysis of the situation. In particular, the ongoing redesign of the FADN could include variables more closely related to knowledge and innovation.

ACKNOWLEDGEMENTS AND FUNDING

The work presented in this paper was carried out within the scope of the Italian National Rural Network (CAP 2014-2020).

AUTHOR CONTRIBUTIONS

A.V.: Conceptualization, Data curation, Writing, Reviewing, and Editing.

F.G.: Conceptualization, Data curation, Writing, Reviewing, and Editing

REFERENCES

Arzeni A., Ascione E., Borsotto P., Carta V., Castellotti T., Vagnozzi A. (2021). Analysis of farms characteristics related to innovation needs: a proposal for supporting the public decision-making process. *Land Use Policy*, 100. DOI: https://doi.org/10.1016/j.landusepol.2020.104892.

Birke F.M., Knierim A., Bae S., Gerster-Bentaya M. (2025). How to comparatively analyse the AKIS across European countries – conceptual foundations and application. *The Journal of Agricultural Education and Extension*. DOI: https://doi.org/10.1080/1389224X.2025.2559583.

Bonfiglio A. (2024). Unveiling innovation imperatives in agriculture: a data-driven framework for identifying latent needs and regional priorities, *Sustainable Futures*, 8, 100273. DOI: https://doi.org/10.1016/j.sftr.2024.100273.

Bruno E., Castellano R., Punzo G. (2025). A longitudinal analysis of local innovation in Italy: How do proximity measures matter? *Spatial Economic Analysis*, 20(1): 33-52. DOI: https://doi.org/10.1080/17421772.2024.2378739.

Capello R., Lenzi C. (2019). Regional innovation evolution and economic performance. *Regional Studies*, 53(9): 1240-1251. DOI: https://doi.org/10.1080/00343404.2018.1502421.

CREA (2017). *La produzione e la diffusione di conoscenza nell'agroalimentare italiano. Soggetti, risorse finanziarie, interventi di promozione*. Monografie dell'Annuario dell'agricoltura. Edizioni CREA, Roma.

Del Puente F., Buonomo S., Sapio S. (2024). Promoting agricultural innovation through EIP-AGRI Operational Groups: insights from the Southern Italian projects. *ECONOMIA MARCHE – Journal of Applied Economics*, XLIII(2).

Del Puente F., Sapio A., Yanhong J., Carl P. (2025). Assessing the impact of a European Union's policy on agricultural innovation in Italy. *Agriculture and Human Values*, 42: 193-212. DOI: https://doi.org/10.1007/s10460-024-10595-y.

Di Santo N, Sisto R., Dragone V., Fucilli V. (2025). Balancing objectivity and subjectivity in agricultural funding: the case of AKIS measures. *Sustainability*, 17(10), 4730. DOI: https://doi.org/10.3390/su17104730.

European Commission (2012). *Communication from the Commission to the European Parliament and the Council on the European Innovation Partnership "Agricultural Policy and Sustainability"*, COM (2012)79 final, Brussels.

European Commission: Directorate-General for Agriculture and Rural Development, ADE s.a, CCRI and ÖIR GmbH, *Evaluation support study on the impact of the CAP on territorial development of rural areas – Socioeconomic aspects*, Publications Office, 2021. https://data.europa.eu/doi/10.2762/483196.

EUROPEAN COMMISSION – Directorate-General for Agriculture and Rural Development – Unit A.3 (2023): Guidelines. *Evaluating the AKIS Strategic Approach in CAP Strategic Plans.*

European Commission (2024). *Study on outcomes achieved by EIPAGRI Operational Group projects under the CAP*, Directorate-General for Agriculture and Rural Development, Brussels.

EU SCAR (2012) *Agricultural Knowledge and Innovation Systems in Transition – A Reflection Paper*, European Commission, Brussels.

EU SCAR (2015). *Agricultural Knowledge and Innovation Systems Towards the Future – A Foresight Paper*, European Commission, Brussels.

EU SCAR AKIS (2019). *Preparing for future AKIS in Europe*, European Commission, Brussels.

FAO (2024). *World Food and Agriculture Statistical Yearbook 2024*, FAO, Rome. https://openknowledge.fao.org/handle/20.500.14283/cd2971en.

Giarè F., Vagnozzi A. (2022). Governance's effects on innovation processes: the experience of EIP AGRI's Operational Groups (OGs) in Italy. *Italian Review of Agricultural Economics*, 76(3): 41-52. DOI: https://doi.org/10.36253/rea-13206.

Ingram J., Dwyer J., Gaskell P., Mills J. (2018). Reconceptualising translation in agricultural innovation: a co-translation approach to bring research knowledge and practice closer together. *Land Use Policy*, 70: 38-51. DOI: https://doi.org/10.1016/j.landusepol.2017.10.013.

Knierim A., Boenning K., Caggiano M., Cristóvão A., Dirimanova V., Koehnen T., Labarthe P., Prager K. (2015). The AKIS concept and its relevance in selected EU member states. *Outlook on Agriculture*, 44(1): 29-36.

Kok K.P.W., Klerkx L. (2023). Addressing the politics of mission-oriented agricultural innovation systems. *Agricultural Systems*, 211, 103747. DOI: https://doi.org/10.1016/j.agsy.2023.103747.

Kountios G., Kanakaris S., Moulogianni C., Bournaris T. (2024). Strengthening AKIS for sustainable agricultural features: insights and innovations from the European Union: a literature review. *Sustainability*, 16, 7068. DOI: https://doi.org/10.3390/su16167068.

Labarthe P., Beck M. (2022). CAP e servizi di consulenza: dai sistemi di consulenza agricola al supporto all'innovazione. *EuroChoices*, 21: 5-14.

Masi M., De Rosa M., Vecchio Y., Bartoli L., Adinolfi F. (2022). The long way to innovation adoption: insights from precision agriculture. *Agricultural and Food Economics*, 10. DOI: https://doi.org/10.1186/s40100-022-00236-5.

Mikolič S., Slavič I.P. (2025). Exploring regional disparities and stakeholder engagement in Slovenian EIP-AGRI projects. *Revija za Geografijo – Journal for Geography*, 20(1): 89-104. DOI: https://doi.org/10.18690/rg.20.1.5041.

OECD/Eurostat (2018). *Oslo Manual 2018: Guidelines for Collecting, Reporting and Using Data on Innovation, 4th Edition*, OECD Publishing, Paris. DOI: https://doi.org/10.1787/9789264304604-en.

OECD (2019), Innovation, Productivity and Sustainability in Food and Agriculture: Main Findings from Country Reviews and Policy Lessons, OECD Food and Agricultural Reviews, OECD Publishing, Paris. DOI: https://doi.org/10.1787/c9c4ec1d-en.

Oliveira M.d.F., Gomes da Silva F., Ferreira S., Teixeira M., Damásio H., Dinis Ferreira A., Gonçalves J.M. (2019). Innovations in Sustainable Agriculture: Case Study of Lis Valley Irrigation District, Portugal. *Sustainability*, 11(2), 331. DOI: https://doi.org/10.3390/su11020331.

Proietti P., Cristiano S. (2023). Innovation support services: an evidence-based exploration of their strategic roles in the Italian AKIS. *The Journal of Agricultural Education and Extension*, 29(3): 351-371. DOI: https://doi.org/10.1080/1389224X.2022.2069828.

Rete Rurale Nazionale (2020). *L'Italia e la Pac post 2020 - Policy Brief, OS: Promuovere e condividere conoscenze, innovazione e processi di digitalizzazione nell'agricoltura e nelle aree rurali incoraggiandone l'utilizzo*, Rete Rurale Nazionale, Rome.

Rete Rurale Nazionale (2023a). *Interventi AKIS nel Piano Strategico della PAC 2023-2027*, PSRhub, Rome.

Rete Rurale Nazionale (2023b). *Le azioni per il trasferimento della conoscenza e dell'innovazione Lo stato di avanzamento delle Misure 1, 2, 16.1 e 16.2 a dicembre 2022*, Rete Rurale Nazionale, Rome.

Sutherland L.-A., Prager K. (2025). Including AKIS in the 2023 CAP Strategic Plans: what difference has it made? *EuroChoices*. DOI: https://doi.org/10.1111/1746-692x.70011.

Zahran Y., Kassem H.S., Naba S.M., Alotaibi B.A. (2020). Shifting from Fragmentation to Integration: A Proposed Framework for Strengthening Agricultural Knowledge and Innovation System in Egypt. *Sustainability*, 12(12), 5131. DOI: https://doi.org/10.3390/su12125131.

REA | ITALIAN REVIEW OF AGRICULTURAL ECONOMICS

Firenze University Press
www.fupress.com/rea

Citation: Mustafa, Z., Vitali, G., & Canavari, M. (2025). Sustainability and supply response of the sugarcane supply chain in Pakistan. *Italian Review of Agricultural Economics* 80(3): 87-101. DOI: 10.36253/rea-15620

Received: October 3, 2024

Revised: October 6, 2025

Accepted: November 5, 2025

Data Availability Statement: Data will be made available by the corresponding author upon request.

Competing Interests: The Author(s) declare(s) no conflict of interest.

Guest Editor: Anna Irene De Luca

ORCID
ZM: 0000-0003-4664-7718
GV: 0000-0002-7866-5534
MC: 0000-0003-0573-7880

Research article

Sustainability and supply response of the sugarcane supply chain in Pakistan

Zeeshan Mustafa*, Giuliano Vitali, Maurizio Canavari

Department of Agricultural and Food Sciences, University of Bologna, Italy
*Corresponding author. E-mail: zeeshanuaf@gmail.com

Abstract. Agricultural supply response is critical to economic development, particularly in a climate change scenario. This study uses a two-step generalised method of moments approach to examine the supply response of sugarcane to climatic and market factors in Pakistan from 1951 to 2010. The findings reveal a complex dynamic between cultivated area and yield, influenced by speculative behaviours, climatic conditions, regional research and development policies, and production factors. The results emphasise the importance of strategic resource allocation to mitigate climate impacts, develop drought-resistant varieties, subsidise farm inputs, enhance advisory services, and research and development funding to support sugarcane intensification and biodiversity protection.

Keywords: climate change adaptation, market dynamics, crop intensification, time series analysis.
JEL codes: Q01, Q13, Q16.

HIGHLIGHTS

- Farmers' crop and land decisions are highly responsive to price incentives.
- Policymakers must grasp supply responsiveness to avoid agri-food disruptions.
- The supply response of sugarcane in Pakistan highlights strategic resource allocation for sugarcane intensification and biodiversity.

1. INTRODUCTION

The vulnerability and proneness of agri-food supply chains depend on the responsiveness of the dynamic agricultural production system (Edison *et al.*, 2020; Gliessman, 2021), which may lead to food insecurity (Chavas *et al.*, 2022), especially in a climate change scenario. These dynamic agricultural production systems are often estimated through agricultural supply response (ASR), that is, the acreage, yield, or output response to economic and/or non-economic incentives. Researchers have studied specific and/or isolated impacts of ASR – for example, output prices (Bor, Bayaner, 2009), input cost (Mustafa *et al*., 2016), and climate (Bassu *et al*., 2014; Chavas, Di Falco, 2017) – under specific policy settings (Lavanya, Manjunatha, 2025). ASR plays a central role in shaping farm design (Kalaiselvi *et al*., 2024) and agricultural policy (Doukas *et al*., 2022) to ensure sustainable and resilient agri-food supply chains.

In agricultural policy, prices influence farmers' planning decisions regarding crop production and land use (Osborne, 2005). Low prices for farmers will discourage production, leading to food and primary input shortages that reduce economic development (Abrar *et al*., 2004). Price elasticity (the percentage rate of price changes) is mainly used for such policy evaluations, including support price and buffer stock operations, to estimate the demand/supply gap in agriculture (Haile *et al*., 2016). Therefore, within agri-food systems, the ASR of acreage and yield controls prices and bridges any demand/supply gaps for a crop (Nkang *et al*., 2007).

There are several complex, interconnected subsystems in agri-food systems in which key actors evolve dynamically. Each subsystem has unique features and behaviours that researchers must consider before developing models to ensure they obtain plausible estimates. (1) At the farm level, production is a dynamic phenomenon, and farmers are risk-averse (Antle, 1983), so it is necessary to include risk and price uncertainty (Chavas *et al*., 2022). (2) Each crop has a unique biological cycle, which requires consideration of crop- and location-specific characteristics. (3) It is necessary to include theoretically and mathematically sound/consistent indicators – for example, a clear differentiation among climate change (a decades-long and persistent long-term shift), climate variability (shorter-term fluctuations), and climate extremes (rare or unusually intense events). Moreover, technology is not linear, and its impact cannot be simplified by using time trends as a proxy for technological progress (Yu *et al*., 2018). (4) At the market level, the roles of buyers, intermediaries, and sellers are important within the existing marketing structure (Fligstein, Calder, 2015) as well as the prevailing government policies/regulations. Some researchers have already studied the problem in agricultural marketing, irrespective of ASR (Gohain, 2018; Skogstad, 1993). However, the limited data available means that these aspects are often overlooked in ASR research. As noted by Mbua, Atta-Aidoo (2023), there is a growing need for studies to inform policymakers about the drivers of agricultural supply chains and to provide a pathway for innovating agri-food systems.

Sugarcane – a crop highly sensitive to growing conditions – is a source of livelihood for around 100 million people worldwide (FAO, 2019). Pakistan is one of the top sugarcane producers in Asia, has the fastest annual population growth rate (1.9%), high per capita sugar consumption (24.64 kg), and an increasing trend in refined sugar imports (28,760 metric tons). Based on these factors, a recurring sugar crisis is looming (Pakistan Sugar Mills Association, 2021). The Government of Pakistan has implemented the Sugar Factories Control Act (1950) to regulate the sugarcane supply. This act established a sugarcane reservation area, restricting sugarcane growers' options for selling their crop to only one designated mill and leaving no alternative buyers. Although the sugarcane zoning system was discontinued in 1987, new mills still experience barriers to entry. The millers (allegedly) collude with officials to circumvent loopholes (Pirzada *et al*., 2023), discouraging competition, increasing inefficiencies in ASR, and strengthening a monopsonistic regime (Alston *et al*., 1997).

The present study is designed to integrate multifaceted aspects of ASR related to sugarcane, the agricultural region, and climate change, and its responsiveness in the short and long run within one modelling framework via a two-step generalised method of moments with instrumental technique (GMM-IV). Our study is the first of its kind. We have attempted to include the following: (1) all important variables after robust theoretical consideration, such as climatic (change or variability) variables considering crop phenology, disaggregated drought estimates for climate extremes, and actual research and development (R&D) expenditures as a proxy for technological improvements; (2) the historical evolution of acreage and yield under government regulatory restrictions; and (3) a plausible estimation of total ASR (i.e., both acreage and yield responses). The estimates presented in this paper may be further improved based upon the availability of data from the year 2010 onwards, including data on agricultural-marketing-related problems (e.g., delays in procurement [crushing season], the length of the crushing season, the wait time for weighing and unloading, a deduction in payments, and the timing of announcement of crop support price, among other factors).

The remainder of the article is organised as follows. Section 2 provides a literature review that highlights the importance of sugarcane within the agri-food system and the rationale for this research. Section 3 introduces the data selected, the construction of the derived variables, and the statistical analysis. Section 4 covers the results and discussion, and Section 5 summarises the main findings and policy implications. In the rest of this paper, we have used some terms interchangeably: cultivated area for acreage or crop area; agricultural production region for region or district; and climate dynamics for climate change as a whole (long-term gradual change), climate variability (short-term abrupt changes), and climate extremes or shocks (rare or unusual incidents).

2. LITERATURE REVIEW

The ASR literature has two distinct streams. The first stream is dominant and related to crop duration: annual (Abrar *et al.*, 2004; Lobell *et al.*, 2013, 2014) or perennial (Devadoss, Luckstead, 2010; Wani *et al.*, 2015). Researchers have also considered risks and uncertainty (Antle, 1983). Price volatility is the primary source of uncertainty (Mustafa *et al.*, 2024); it affects both productivity – technical efficiency (Đokić *et al.*, 2022) and optimal resource use – and allocative efficiency (Mivumbi, Yuan, 2023) and, hence, overall economic efficiency (Chen *et al.*, 2023). The second stream has focused on devising a sophisticated methodological framework to obtain plausible estimates (Elnagheeb, Florkowski, 1993; Mearns *et al.*, 1997; Mendelsohn *et al.*, 1994). However, the estimates are not consistent or robust, so it is necessary to systematically integrate the climate, crop, and economic results from different types of models. Results from crop- and location-specific models (Ray *et al.*, 2012) can be integrated to assess the resilience of the agroeconomic system to climate change (Chavas, Di Falco, 2017; Nelson *et al.*, 2014) and to better understand its underlying marketing structures.

There have been few studies on the responses of field crops to gradual climate changes at a decadal scale. Several researchers have investigated the impacts of seasonal climate variability on crop production (Chen, Chang, 2005; Tao *et al.*, 2006). The effects of extreme events, such as drought, are often ignored and/or aggregated, leading to a failure to depict ground-level water conditions. These climate extremes also affect farmers' expectations and risk perceptions throughout a crop cycle (Yu *et al.*, 2021). Other studies have excluded key variables such as prices, which are important to capture the cyclical behaviour over time (Von Cramon-Taubadel, Goodwin, 2021), the irrigated land share (Hertel, 2011), fertiliser consumption (Boansi, 2014), and the biological cycle of crops (Devadoss, Luckstead, 2010). These omissions may result in implausible or even biased estimates (Alston, Chalfant, 1991).

In Pakistan, there is a dearth of research on sugarcane. The first reported study on sugarcane acreage response included only the relative price index, based on 28 years of time-series data (from 1915-1916 to 1943-1944), from the undivided Punjab region of India and Pakistan (Krishna, 1963). Ali (1990) included sugarcane in evaluating production supply response, but only with respect to fertiliser price. Wasim (1997) focused on the response of sugarcane (irrigated acreage) to price and yield risk, along with plant protection measures and sugar production, based on 21 years of data (from 1972-1973 to 1993-1994) from five districts of the Sindh province. Mushtaq, Dawson (2002) examined the response of sugarcane acreage to wholesale prices, irrigated area, and sowing-season rainfall using 36 years of data (1960-1996) from Pakistan. Shafique *et al.* (2007) analysed the supply response of acreage and yield to the crop's own price, the cotton price, canal water availability at sowing, fertiliser prices, and rainfall during the sowing period, based on 32 years of data (1970-2001) from various agro-ecological zones in Punjab. At the country level, Khan, Hussain (2007) studied the sugarcane acreage response to the support price, water availability, and yield using 18 years of data (from 1985-1986 to 2003-2004), while Nosheen, Iqbal (2008) estimated acreage response to sugarcane price and yield only, based on 36 years of data (1970–1971 to 2006-2007). Yaseen, Dronne (2011) estimated the response of sugarcane output (gross product per hectare) to the sugarcane area, price, and yield using only 42 years of data (1966-2008). Saddiq *et al.* (2013) studied the response of sugarcane crop area to prices, yield, and rainfall using 42 years of data (1970-2011) from the North West Frontier Province (now called Khyber Pakhtunkhwa [KP]).

The synthesis of previous research from Pakistan raises serious concerns about the plausibility of ASR estimates. To date, the long-term climate dynamics for sugarcane have not been empirically quantified with advanced methods. When modelling dynamic production systems, endogeneity often poses a serious challenge, making ordinary least squares estimates unreliable. To address this issue, robust estimators that are consistent in the presence of heteroscedasticity and autocorrelation – such as those obtained with the GMM-IV model – are more appropriate. However, most previous studies have relied on low-frequency, aggregated data at the national or provincial level. High-frequency panel data, by contrast, can reveal significant differences between micro- and macro-level supply responses (Wu, Adams, 2002). Aggregating parameters across broader geographic areas (e.g., from district to province) alters their underlying distributions and reflects different market and policy environments. In addition, earlier studies have rarely accounted for sugarcane's biological cycle or technological changes, both of which are crucial for accurate estimation. These omissions can distort the representation of macro-level dynamics and lead to biased or inconclusive results (Hannay, Payne, 2022). In ASR analysis involving acreage, it is essential to understand the historical evolution of cultivated area and yield (Babcock, 2015) before quantifying their roles within agri-food systems. Therefore, it is necessary to revisit ASR analysis using high-frequency, crop- and location-specific data to generate more concrete insights into the resilience and sustainability of Pakistan's sugarcane supply chain.

3. METHODOLOGY

We performed a descriptive analysis to understand the historical evolution of the cultivated area and yield; it involves a description of farm management and land use under prevailing climatic and marketing conditions. We performed an empirical analysis to estimate and revalidate ASR for the sugarcane crop at the district level.

3.1. Empirical model

We quantified the behaviour of the farmers' decision variable(s) by using the Nerlovian reduced-form model (Ngoc *et al*., 2022). This model has the advantage of capturing the speed of adjustment and the rate of change in the response variable. In this model, let B_t be the dependent variable and Z_t be the vector of regressors, including price and non-price factors. The Nerlovian reduced-form model distinguishes between the actual level of the variable, B_t, and the desired level, B_t^d, which the farmer aims to achieve based on the values of the decision variables (Equation 1).

$$B_t^d = \theta' Z_t + \varepsilon_{1t} \tag{1}$$

The actual level then adjusts towards this level, according to Equation (2):

$$B_t = B_{t-1} + \lambda \left(B_t^d - B_{t-1}\right) + \varepsilon_{2t} \tag{2}$$

where λ is the speed adjustment to the desired level. This means that the change in any given period is proportional to the gap between the actual and desired levels in the previous period (i.e., $B_t^d - B_{t-1}$), so our model is dynamic (Tenaye, 2020). When this parameter is close to zero, adjustment is slow, while a high value indicates fast adjustment.

For the present study, we specifically derived Equations (3) and (4) for the current sugarcane cultivated area (A_t in 000 ha) and yield (Y_t, in tons/ha) responsiveness in the i^{th} districts.

$$A'_{it} = a_0 + a_1 P'_{it-1} + a_2 Z'_{it} + a_3 A'_{it-1} + \mu_{it} \tag{3}$$

$$Y'_{it} = \beta_0 + \beta_1 P'_{it-1} + \beta_2 Z'_{it} + \beta_3 Y'_{it-1} + \vartheta_{it} \tag{4}$$

where P is the price of produce and fertilisers (cost), Z is an array of exogenous variables (non-price factors), (α_0, β_0) is the offset parameter, and (μ_{it}, ϑ_{it}) are the noise components. α and β are short-run elasticities with respect to price and non-price factors for the cropped area and yield, respectively.

All variables are expressed in the logarithmic form (*e.g.,* A' = log A), while allowing the total production (TP') response to be expressed in logarithmic terms as a sum of the area and yield responses ($TP' = A' + Y'$). When the area (a_3) and yield (β_3) elasticities are higher, farmers who cultivate sugarcane make faster adjustments (Wang *et al*., 2020).

We also hypothesise that growers are rationally efficient (Liu *et al*., 2016) and all long-run elasticities exceed the short-run elasticities (Tenaye, 2020). Farmers quickly adjust their cultivated area to the desired level if the adjustment coefficient is close to 1 and vice versa. In addition, the presence of lagged dependent variables can lead to autocorrelation. The two-step GMM-IV model (Baum *et al*., 2003) is appropriate if the error distribution is not independent of the distribution of the regressors. We used the GMM-IV model to compute the area and yield response estimates to ensure robust homoscedasticity and autocorrelation consistency while treating lagged dependent and price variables as predetermined (i.e., instruments).

3.2. Construction of the variables

We considered sugarcane fertiliser uptake and diammonium phosphate (DAP) prices as essential farm inputs and precipitation/temperature as essential climatic variables (Chavas *et al*., 2019). Because sugarcane is sensitive to conditions at each stage of growth, we computed a 30-year rolling average of climatic variables for each growth stage (He *et al*., 2020; Rezaei *et al*., 2018). In other words, the climatic variables computed for 1981 are the average of the previous 30 years (1951–1980), and the same approach is applied for the other variables and times (Van Der Wiel, Bintanja, 2021). We considered the sample from 1981 to 2010 for further analysis.

To characterise the variability and distribution of climatic conditions, we calculated the coefficients of variation (climate anomalies) for monthly precipitation and temperature, accounting for the sugarcane growth stages. We identified four key stages based on consultations with national sugarcane experts in Pakistan (personal communications) and the literature (Thornton *et al*., 2014): sowing and germination (January-March), tillering (April-June), grand growth (July-August), and maturity and harvesting (September-November). Given the importance of drought in influencing the area and yield responses in water-scarce districts (Shehzad *et al.*, 2022), we computed the Pálfai Drought Index (PaDI) using Equation (5) to quantify the impact of extreme events at the district level (Jahangir, Danehkar, 2022).

$$PaDI_0 = \frac{\frac{\left[\sum_{i=apr}^{aug} T_i\right]}{5} * 100}{c + \sum_{i=oct}^{sep} (P_i * w_i)} \quad (5)$$

where $PaDI_0$ is the base value of the drought index (°C/100 mm), T_i is the monthly mean temperature from April to August (°C), P_i is the monthly sum of precipitation from September to October (mm), w_i is a weighting factor, and c is a constant (10 mm).

3.3. Data

We based the analyses on a monthly time series from 1951 to 2010 from 20 leading sugarcane-producing districts in Pakistan. After 2010, several new districts were created, and their historical data became unavailable. Therefore, the final sample was restricted to 2010.

We considered districts with sufficiently high sugarcane production (>5% share in national sugarcane production) and the availability of meteorological observations and the existence of a district from the 1950s (Hazrana *et al.*, 2020). Based on these criteria, we selected nine districts from Punjab, eight from Sindh, and eight from KP. The Pakistan Bureau of Statistics (PBS) provides district-level data on area, yield, total macronutrient uptake (NPK nutrients), crop prices, and fertilisers. The National Agricultural Research Centre (NARC) in Islamabad, Pakistan, provides the R&D expenditures. The Pakistan Meteorological Department (PMD) provides district-level data on climatic variables. Table 1 reports the variables and their sources, including the derived variables.

4. RESULTS AND DISCUSSION

4.1. Descriptive analysis

Our analysis shows that the farmers' allocation decisions result in significant variations in the sugarcane-cultivated area and yield. In Sindh, the area is around 40,000 ha, and the yield is around 14 tons/ha (Table 2). These values for this province have been ascribed to the appearance of new sugar mills, a favourable environment for cultivation, and improved technical and allocative efficiency of farmers from 1981 to 2010 (Khushk *et al.*, 2011).

There is a skewed, intermittent distribution of R&D expenditures across provinces. From 1981 to 2010, the highest R&D expenditure was in Punjab (around 14 million) and the lowest in KP (0.20 million).

The highest annual precipitation was in KP (41 mm), and the highest monthly mean temperature was in Sindh (28°C). Although the average temperature is almost equal to the optimal value for sugarcane (27°C; Ebrahim *et al.*, 1998), there are considerable variations throughout the sugarcane crop cycle. Precipitation and temperature variability are more pronounced in KP (12 points) and Sindh (5 points). In contrast, the coefficients of variation of precipitation and temperature shocks are higher in Sindh (125%) than in KP (40%).

There has been a severe drought-like situation in Punjab, compared with Sindh (moderate drought) and KP (mild drought), across the sugarcane-producing districts (Figure 1). This situation is another reason for KP's high natural potential for sugarcane production, compared to Punjab.

4.2. Area and production trends

Figure 2 presents the sugarcane cultivated area and production from 1981 to 2010. The changes over time reflect the growers' choices and cropland planning. The only district to show significant growth in sugarcane-cultivated land is D.I. Khan in KP. These increases in cropland result from adjustments in cropping patterns or the occupation of pristine land, especially in the D.I. Khan district. The recent study by Hussain, Khan (2021) supports our results, as they reported a higher deforestation rate in the D.I. Khan district.

During 1999-2000, there were spikes in production in five districts: Peshawar in KP; Muzaffargarh in Punjab; and Mirpur Khas, Sanger, and Thatta in Sindh. During this time, the recorded production harvested led to a domestic surplus in the sugarcane supply, despite a reported 13% reduction in cultivated area. The boom cycle ended within the next three years; as a result, sugar prices remained stagnant (Pakistan Sugar Mills Association, 2000). Production offset the trend of increased cultivated area in the Gujrat, Lahore, and Sargodha districts, especially in 2004-2005.

The reason for such trends can be attributed to different growth rates in cultivated area (0.4%) and yield (2.9%), and to an increase in sugarcane price support (1.5 times from 2005 to 2010) in Punjab (USDA-FAS, 2021). In the Bahawalnagar district (Punjab), farmers have exchanged land for more profitable crops, such as rice, resulting in a drastic decrease in acreage. Overall, the results indicate no uniform relationship across the

Table 1. Detailed description of the variables used in this study (for the sample from 1951 to 2010).

Variable	Description	Units (estimation)	Sources
A	Sugarcane cultivated area	(× 1000) hectares	PBS
Y	Sugarcane yield	ton/ha	
***Prices and costs**			
CP	Cotton	PKR/40 kg	
MP	Maize		
RP	Rice		
SP	Sugarcane		
WP	Wheat		
DAP	Diammonium phosphate	PKR/50 kg	
Inputs			
TNU	Total nutrient uptake	NPK kg/hectares	National Fertilizer Development Centre (NFDC)
NU	Nitrogen uptake	kg/hectares	
PU	Phosphorus uptake		
KU	Potassium uptake		
PK	Phosphorus/potassium nutrient ratio	Index	Own calculations
PNPK	Phosphorus/total nutrient ratio		
PN	Phosphorus/nitrogen nutrient ratio		
PIC	Irrigated overcultivated area ratio		
R&D	Research and development expenditures	PKR (millions)	NARC
Climate			
Prec.	Average rainfall	Moving average (mm)	PMD
Temp.	Average temperature	Moving average (°C)	
PG	Precipitation at germination	Average (mm)	Own calculations
PT	Precipitation at tillering		
PGG	Precipitation at grand growth		
PM	Precipitation at maturity		
PS	Precipitation shocks	Index	
PSG	Precipitation shocks at germination		
PST	Precipitation shocks at tillering		
PSGG	Precipitation shocks at grand growth		
PSM	Precipitation shocks at maturity		
TG	Temperature at germination	Average (°C)	
TT	Temperature at tillering		
TGG	Temperature at grand growth		
TM	Temperature at maturity		
TS	Temperature shocks	Index	
TSG	Temperature shocks at germination		
TST	Temperature shocks at tillering		
TSGG	Temperature shocks at grand growth		
TSM	Temperature shocks at maturity		
PaDI	Pálfai Drought Index	Index	Jahangir, Danehkar, 2022

Notes: In actual model estimations, we have used real crop and fertilisers prices after deflating wtih consumer price index (CPI), retrieved from the World Bank. All variables were used in the logarithmic form except for drought. Note that *TNU* considers the use of nitrogen, phosphorus, and potassium fertilisers.

districts. Farmers are making quick adjustments in area allocation and optimising farm inputs as mitigation and adaptation strategies to offset the negative impacts of climate change.

4.3. Dynamic changes

This section focuses on understanding the magnitude and speed of technological adjustments (Table 3). We used the under-identification ($p < 0.05$), weak identi-

Table 2. Descriptive statistics of the variables (for the sample from 1981 to 2010)

Variable	KP		Punjab		Sindh	
	Mean	SD	Mean	SD	Mean	SD
A	30.03	18.17	57.27	32.72	40.51	39.78
Y	41.85	6.77	42.32	6.92	46.67	13.44
TNU	582.65	452.02	913.36	1533.25	1341.98	986.64
CP	851.75	288.77	851.75	288.15	851.75	288.25
MP	315.83	87.69	316.60	82.37	319.93	79.56
RP	672.45	714.05	672.45	710.05	672.45	710.30
SP	45.66	28.33	45.30	28.03	46.07	28.31
WP	391.70	277.26	391.70	275.70	391.70	275.80
DAP	869.23	645.00	869.23	641.39	869.23	641.61
PaDI	4.83	2.02	11.02	6.04	6.74	6.91
PS	7.00	1.41	6.86	3.00	5.52	2.39
TS	1.99	0.59	2.59	0.25	3.05	0.51
PIC	1.16	0.44	0.94	0.35	0.70	0.31
PKR.	54.76	68.16	38.65	69.05	24.31	20.72
PNPK	0.19	0.06	0.18	0.05	0.18	0.04
PN	0.24	0.11	0.229	0.08	0.24	0.12
Prec.	40.95	13.72	34.76	18.43	15.54	8.60
Temp.	22.33	2.28	25.65	1.56	27.51	1.21
R&D	0.20	0.23	14.20	10.91	2.04	3.00

Notes: See Table 1 for a description of each variable. For simplicity, the interactions of the climactic variables (*Temp.* and *Prec.*) with crop phenology have been omitted.

fication (F = 1742.677), and over-identification ($p > 0.05$) tests to validate the results.

The lagged coefficient is higher for the area than for the yield (0.94 vs 0.57), which agrees with the outcomes described in the previous section (Table 3). The higher sugarcane production may be attributed to horizontal expansion (which can be related to the imperfections of the market). The adjustment coefficients for the area and year are <1, indicating a slow adjustment in the long-run equilibrium. The current pace of the farmers' decisions is expected to bring the yield back to equilibrium in approximately 2.3 years in the case of an unexpected (price and non-price) shock.

We addressed the sugarcane supply-climate change nexus using linear and nonlinear parameterisations of climatic variables. Precipitation shocks at grand growth (0.39%) and maturity (0.51%) resulted in positive shifts, as indicated by a combined increase of 900 ha in sugarcane area allocation. A pronounced (non-linear) impact of precipitation at the tillering stage resulted in a 0.20% increase (an additional 200 ha) from 1981 to 2010. Optimal rainfall is crucial for a higher number of tillers and thus a higher sugarcane yield (Vasantha *et al.*, 2012).

The cultivated area is more responsive to the linear temperature changes than to its non-linear fluctuations. There is an increase of approximately 470 ha in sugarcane land due to a 1% increase in temperature at the tillering stage. In contrast, temperature at the grand growth stage shows a parabolic pattern, as indicated by the significant squared term in the model (i.e., TGG^2). The temperature increases linearly at the maturity stage and has a significant negative (-0.44%) short-run elasticity, resulting in a 440-ha decrease in the sugarcane-cultivated area (de Medeiros Silva *et al.*, 2019).

The average temperature in our sampling framework during this stage was 25°C, whereas the optimum temperature for sucrose accumulation at maturity is 12-14°C (Verma *et al.*, 2019). The long-term implications of these results include changes in production (food availability), disruptions in food volume, and alterations in trade patterns in domestic and international markets (Santeramo *et al.*, 2021).

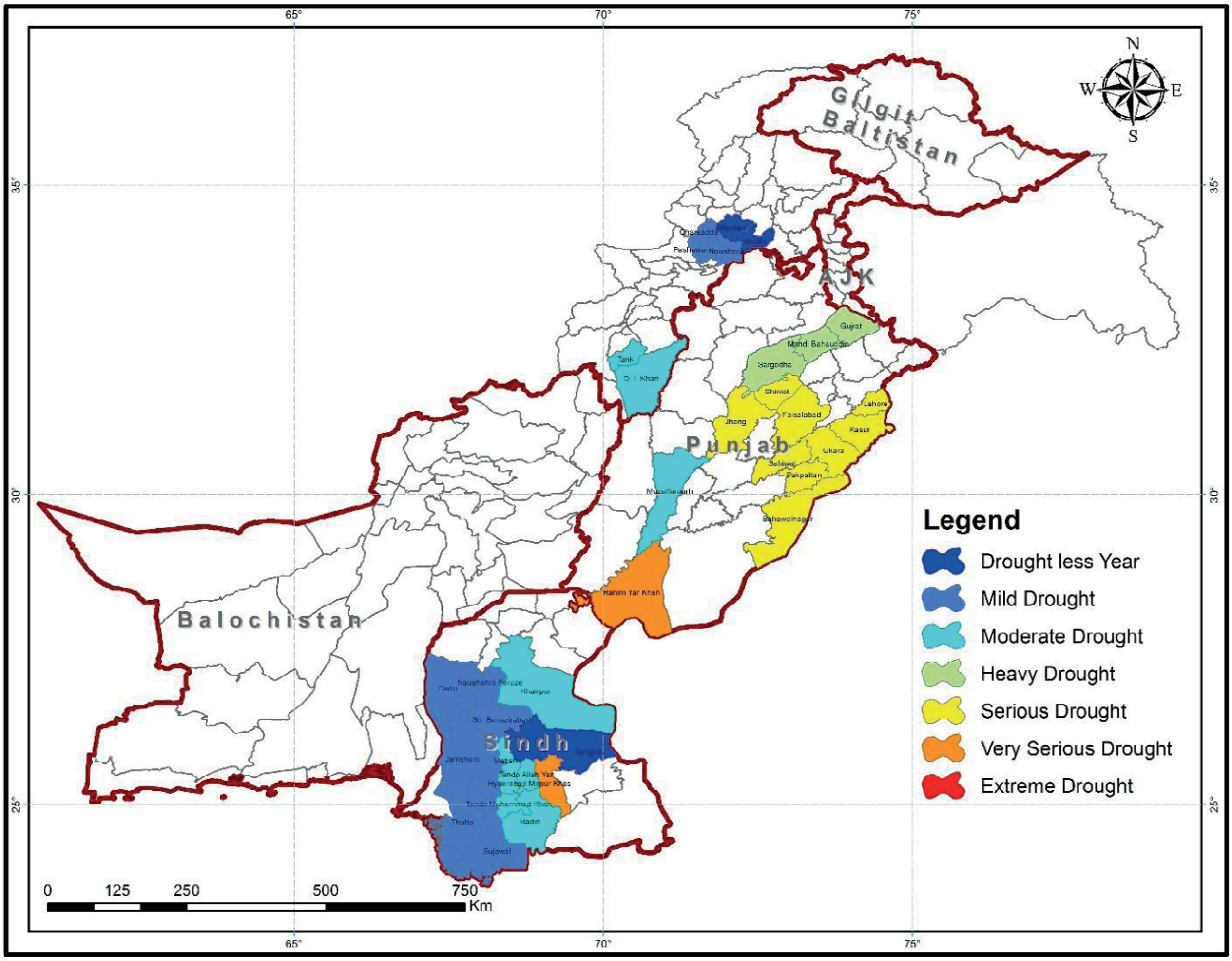
It appears that R&D expenditure significantly (and adversely) affects the yield response, with a short-run elasticity of -0.13%. In Pakistan, R&D investment in cereals has been higher than in sugarcane. Most R&D expenditure has focused on maintaining sugarcane yield rather than enhancing it (Abraham, Pingali, 2021). These results highlight the uncertainty that arises from underinvestment in R&D (Pardey *et al.*, 2006) and imperfect market conditions (Mai, Lin, 2021), questioning the validity of previous computed results.

Regarding the farm inputs, the short-run elasticity of the P:N ratio is 0.25%, resulting in a higher area response than the P:K ratio (-0.02%) and the P:NPK ratio (-0.19%), decreasing the sugarcane area response. This result indicates that the imbalance in fertiliser use stems from the use of potassium nutrients, which may reduce the sugarcane crop area. These imbalances can be ascribed to a lack of subsidies and increasing prices (Ali *et al.*, 2016).

According to economic theory, we should expect important effects from complementary crops (Santeramo *et al.*, 2021). The cotton price has significant positive short-run elasticities for area (0.09%) and yield (0.36%). Specifically, growers are unable to convert the area used to cultivate sugarcane to area used to cultivate cotton, as the sowing time overlaps with sugarcane (starting in mid-February). The yield response to cotton prices is higher, as sugarcane farmers could earn higher profits in September from conventional cotton harvesting. Farmers can purchase inputs used to grow sugarcane on time, just before the crop matures.

The relationship between sugarcane price and area (yield) is negative, in contrast to standard production theory (Yu *et al.*, 2012). The growers reallocate only

Figure 1. The drought situation according to the PaDI index categories within the Pakistani sugarcane-producing districts from 1981 to 2010.



Note: The graph was prepared based on the 2017 district boundaries. The PaDI (°C/100 mm) categories are: drought-less year (<4); mild drought (4-6); moderate drought (6-8); heavy drought (8-10); serious drought (10-15); very serious drought (15-30); and extreme drought (>30).

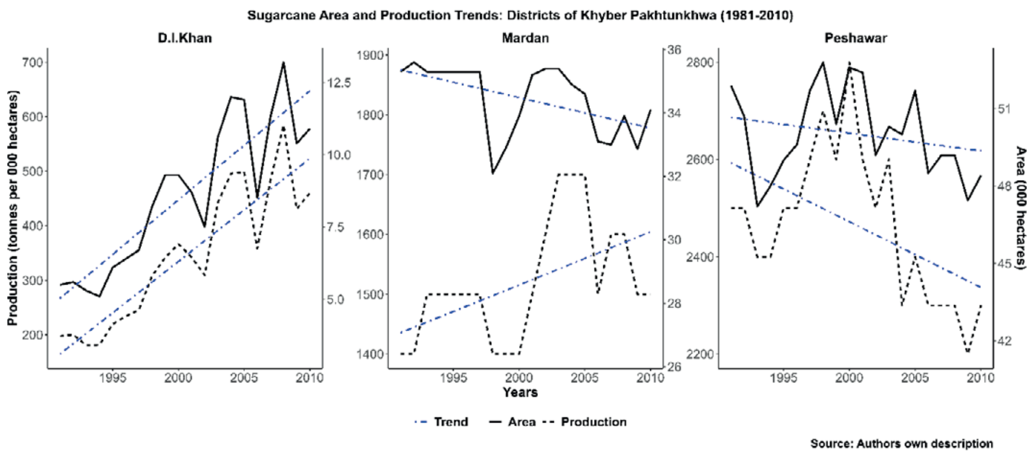
around one-fourth of their desired level within 1 year as their price elasticity is -0.26%. This could be attributed to delayed or reduced payments by sugar mills compared with the announced prices. The beginning of the late cane-crushing season is another important factor. These adjustments are further exacerbated by increased DAP prices and an additional 0.09% reduction in the sugarcane area in the short run. The impacts of increased DAP prices are more pronounced in the yield response, with approximately a 30% reduction in yield accounting for these price surges.

4.4. Elasticity of price and non-price factors

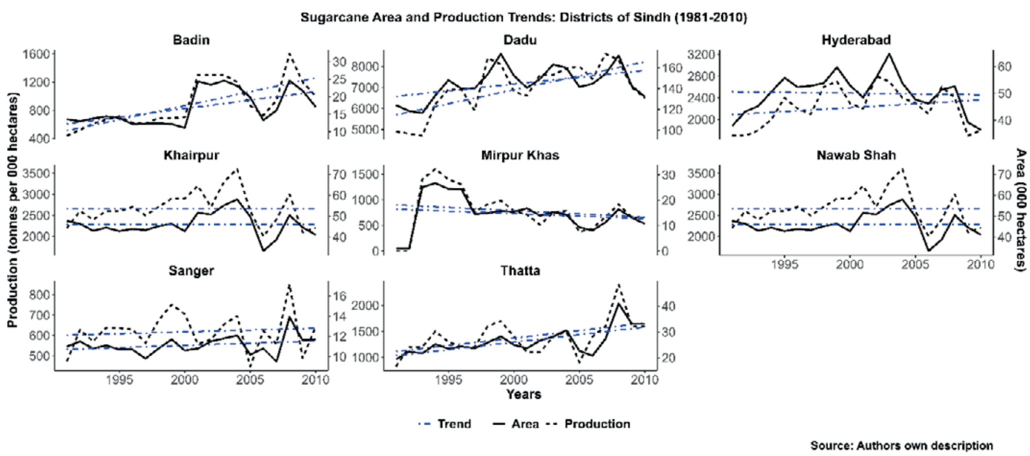
The rice and wheat prices have positive short-run elasticities, while the sugarcane price has a negative short-run elasticity for the area (Figure 3). Overall, the short-run price and non-price elasticities for the area response are very small, except for precipitation and temperature at the grand growth stage ($\beta < 0.50$). Regarding the yield response, four non-price factors – precipitation at grand growth (0.84%), temperature at germination (-0.67%), temperature at grand growth (-0.59%), and temperature at maturity (0.51%) – show higher short-run elasticities. Overall, price leads to positive changes in the sugarcane supply response: a 1% average price increase may increase the supply response by 0.07% in the long run. Non-price factors, such as precipitation and temperature, have negative long-run elasticities. This outcome confirms that the average non-price supply response is higher than price responses, and in the long run, acreage does not increase with the price (Siegle *et al.*, 2024).

Figure 2. District-wise sugarcane area and production trends in (a) KP, (b) Sindh, and (c) Punjab from 1981 to 2010.

a



b



c

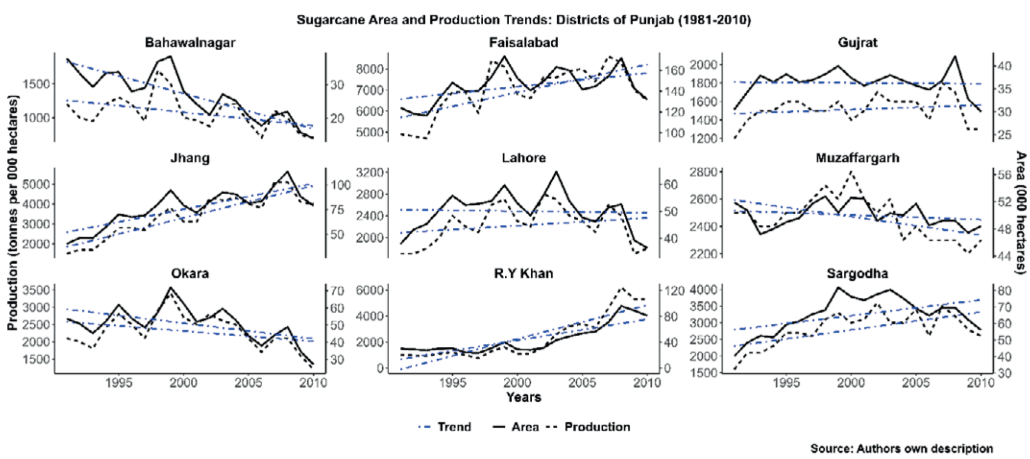


Table 3. The estimated sugarcane supply response in selected Pakistani districts (1981-2010)

Variable	Area (× 1000 hectares)	Yield (tonnes per hectare)	Variable	Area (× 1000 hectares)	Yield (tonnes per hectare)
	β ± standard error	β ± standard error		β ± standard error	β ± standard error
R&D	0.014 ± 0.017	-0.127 ± 0.072**	*A (t-1)*	0.936 ± 0.020***	-
PIC	0.050 ± 0.026**	-0.084 ± 0.094	*Y (t-1)*	-	0.565 ± 0.062***
PK	-0.016 ± 0.009*	-0.016 ± 0.019	*PN*	0.250 ± 0.143*	0.270 ± 0.538
TT	-0.465 ± 0.192**	0.257 ± 0.792	*PNPK*	-0.193 ± 0.106*	-0.230 ± 0.398
TGG	0.837 ± 0.292***	-0.594 ± 0.975	*Constant*	-0.339 ± 0.120***	0.146 ± 0.317
TM	-0.435 ± 0.227*	0.509 ± 0.825	PT^2	0.202 ± 0.069***	0.059 ± 0.142
PSGG	0.387 ± 0.115***	-0.859 ± 0.624	TGG^2	0.081 ± 0.048*	-0.180 ± 0.132
PSM	0.506 ± 0.222**	-0.216 ± 0.506	*TSG*	-0.302 ± 0.174*	0.346 ± 0.760
TG × PG	-0.148 ± 0.218	0.934 ± 0.560*	*TST*	0.107 ± 0.051**	0.016 ± 0.131
TT × PT	0.135 ± 0.076*	-0.068 ± 0.253	*CP*	0.090 ± 0.039**	0.360 ± 0.117***
TGG × PGG	0.102 ± 0.049**	-0.247 ± 0.109**	*RP*	0.140 ± 0.043***	-0.006 ± 0.156
DAP	-0.085 ± 0.052	-0.285 ± 0.142**	*SP*	-0.264 ± 0.076***	-0.013 ± 0.181
DAP × CP	-0.133 ± 0.058**	-0.661 ± 0.208***	*DAP × SP*	0.225 ± 0.082***	0.467 ± 0.235**
DAP × RP	-0.286 ± 0.067***	-0.330 ± 0.163**	*DAP × WP*	0.126 ± 0.113	0.420 ± 0.246*

	Area	Yield
Observations	380	380
Under-identification test		
Kleibergen-Paap rk LM statistic	42.912***	55.735***
Weak identification test		
Cragg-Donald Wald F statistic	1742.677^NS	1696.233^NS
Over-identification test		
Hansen J statistic (p-value)	0.237	0.409
F-test for joint significance (p-value)	0.000	0.000

Note: See Table 1 for a description of each variable. All variables are standardised before deflating the price series (crops and fertilisers) with the consumer price index. The reported standard errors are robust to heteroskedasticity and autocorrelation. The coefficients are two-step GMM-IV estimates, including the lagged dependent variable and predetermined price variables. The results for non-significant terms are omitted: *A* (for yield only), and *PaDI*, *PG*, *PT*, *PGG*, *PM*, *TG*, *PSG*, *PST*, *TPG*, *TPM*, PGG^2, PM^2, TG^2, TT^2, TM^2, *TSGG*, *TSM*, *MP*, *WP*, and *DAP × MP* (for area and yield). The asterisks indicate statistical significance: ***p < 0.01, **p < 0.05, and *p < 0.1. NS means not significant.

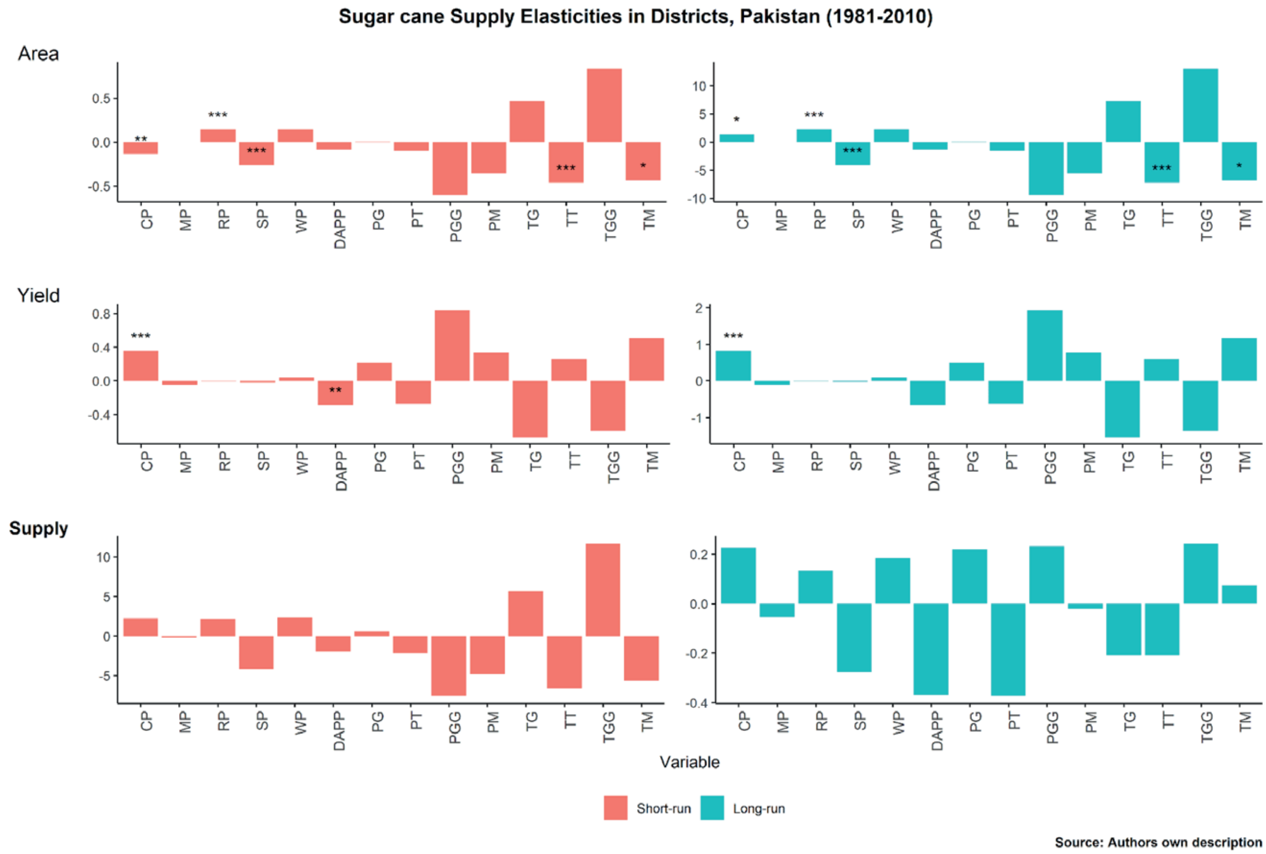
5. CONCLUSIONS

The sustainability of the sugarcane supply chain in Pakistan is at risk. The historic agriculture pricing policy has been inconsistent and ineffective and disincentivised [sugarcane] farmers to ensure the food system is resilient and sustainable. Sugarcane farmers behave idiosyncratically due to incoherent changes in agricultural policy and the inherent, invisible monopsony in the sugar[cane] market. Farmers have had to make trade-offs to find an optimal farm mix. Some of the paradoxical responses of growers may be explained by speculative behaviour driven by persistently higher [cane] sugar prices, leading to an expansion of the sugarcane area rather than an increase in yield.

Our study reveals that the previous sugarcane supply response findings require revalidation because important determinants have been excluded. In the long run, climate change undoubtedly influences the sugarcane supply response. However, these impacts are not uniform across the region or across all crops throughout the entire agricultural production cycle. Temperature has a more pronounced effect on the cropped area than on yield in the absence of sufficient R&D expenditure. These funds are crucial to mitigating the impact of climate change by developing new, area-specific, drought-tolerant, and/or heat-resistant varieties. Moreover, the volatility of input prices (i.e., DAP prices) has led to inefficient resource use and reduced sugarcane productivity.

The sustainability of the sugarcane supply chain depends on the introduction of radical, robust policy initiatives in the sugarcane market. These policy initiatives may be introduced as a sugarcane sector

Figure 3. The estimated short- and long-run supply elasticities of sugarcane in selected Pakistani districts (1981-2010).



Note: The long-run supply elasticities were calculated by dividing the short-run elasticities by (1-β_3). The asterisks indicate statistical significance: ***$p < 0.01$, **$p < 0.05$, and *$p < 0.1$.

reform package. It should provide remedial measures to address the power imbalance between farmers and cane sugar manufacturers, promote competition, eradicate mill monopolistic abuse, and improve industry competitiveness. This can be achieved by removing unnecessary regulatory prerequisites and/or barriers to setting up and running new sugar mills (this issue requires further investigation), and by increasing R&D expenditure to modernise the sugarcane supply chain and ensure its resilience and responsiveness to real-world agricultural challenges.

ACKNOWLEDGEMENTS AND FUNDING

The author (s) are sincerely thankful to Dr Munir Ahmad (Ex-Joint Director), Dr Muhammad Iqbal (Ex-Chief of Research) from the Pakistan Institute of Development Economics, Islamabad, and his team for providing the technical support, data, and guidance in completing this research. We thank Mr Muhammad Bilal Iqbal (Senior Scientific Officer), Climate Change, Alternate Energy & Water Resources Institute (CAEWRI), NARC, Islamabad, for his assistance in finalising Figure 1.> The principal author (ZM) worked as a research fellow at the International Development and Research Centre (IDRC), a Canada-funded project entitled *Climate Change Adaptation, Water and Food Security in Pakistan*.

AUTHOR CONTRIBUTIONS

Z.M.: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Writing—original draft preparation & review/editing.

G.V.: Methodology, Validation, Writing—review and editing, and Visualization.

M.C.: Supervise, Validate, and write—review and edit. All authors have read and agreed to the published version of the manuscript.

REFERENCES

Abraham M., Pingali P. (2021). Shortage of pulses in India: understanding how markets incentivize supply response. *Journal of Agribusiness in Developing and Emerging Economies*, 11(4): 411-434. DOI: https://doi.org/10.1108/JADEE-11-2017-0128.

Abrar S., Morrissey O., Rayner T. (2004). Crop-level supply response by agro-climatic region in Ethiopia. *Journal of Agricultural Economics*, 55(2): 289-311. DOI: https://doi.org/10.1111/j.1477-9552.2004.tb00097.x.

Ali M. (1990). The price response of major crops in Pakistan: an application of the simultaneous equation model. *The Pakistan Development Review*, 29(3/4): 305-325.

Ali M., Ahmed F., Channa H., Davies S. (2016). Pakistan's fertilizer sector: structure, policies, performance, and impacts. *International Food Policy Research Institute (IFPRI)*, Washington, DC, USA.

Alston J.M., Chalfant J.A. (1991). Unstable models from incorrect forms. *American Journal of Agricultural Economics*, 73(4): 1171-1181. DOI: https://doi.org/10.2307/1242445.

Alston J.M., Sexton R.J., Zhang M. (1997). The effects of imperfect competition on the size and distribution of research benefits. *American Journal of Agricultural Economics*, 79(4): 1252-1265. DOI: https://doi.org/10.2307/1244282.

Antle J.M. (1983). Incorporating risk in production analysis. *American Journal of Agricultural Economics*, 65(5): 1099-1106. DOI: https://doi.org/10.2307/1240428.

Babcock B.A. (2015). Extensive and intensive agricultural supply response. *Annual Review of Resource Economics*, 7(1): 333-348. DOI: https://doi.org/10.1146/annurev-resource-100913-012424.

Bassu S., Brisson N., Durand J., Boote K., Lizaso J., Jones J.W., Rosenzweig C., Ruane A.C., Adam M., Baron C., Basso B., Biernath C., Boogaard H., Conijn S., Corbeels M., Deryng D., De Sanctis G., Gayler S., Grassini P., Hatfield J., Hoek S., Izaurralde C., Jongschaap R., Kemanian A.R., Kersebaum K.C., Kumar N.S., Makowski D., Müller C., Nendel C., Priesack E., Pravia M.V., Kim S., Sau F., Shcherbak I., Tao F., Teixeira E., Timlin D., Waha K. (2014). How do various maize crop models vary in their responses to climate change factors? *Global Change Biology*, 20(7): 2301-2320. DOI: https://doi.org/10.1111/gcb.12520.

Baum C.F., Schaffer M.E., Stillman S. (2003). Instrumental variables and GMM: estimation and testing. *The Stata Journal*, 3(1): 1-31. DOI: https://doi.org/10.1177/1536867X0300300101.

Boansi D. (2014). Yield response of rice in Nigeria: a co-integration analysis. *American Journal of Agriculture and Forestry*, 2(2): 15. DOI: https://doi.org/10.11648/j.ajaf.20140202.11.

Bor O., Bayaner A. (2009). How responsive is the crop yield to producer prices? A panel data approach for the case of Turkey. *New Medit*, 4.

Chavas J., Rivieccio G., Di Falco S., De Luca G., Capitanio F. (2022). Agricultural diversification, productivity, and food security across time and space. *Agricultural Economics*, 53(S1): 41-58. DOI: https://doi.org/10.1111/agec.12742.

Chavas J.-P., Di Falco S. (2017). Resilience, weather and dynamic adjustments in agroecosystems: the case of wheat yield in England. *Environmental and Resource Economics*, 67(2): 297-320. DOI: https://doi.org/10.1007/s10640-015-9987-9.

Chavas J.-P., Di Falco S., Adinolfi F., Capitanio F. (2019). Weather effects and their long-term impact on the distribution of agricultural yields: evidence from Italy. *European Review of Agricultural Economics*, 46(1): 29-51. DOI: https://doi.org/10.1093/erae/jby019.

Chen C.C., Chang C.C. (2005). The impact of weather on crop yield distribution in Taiwan: some new evidence from panel data models and implications for crop insurance. *Agricultural Economics*, 33(Supplement): 503-511. DOI: https://doi.org/10.1111/j.1574-0864.2005.00097.x.

Chen S., Yang J., Kang X. (2023). Effect of fiscal expenditure for supporting agriculture on agricultural economic efficiency in central China—a case study of Henan province. *Agriculture*, 13(4): 822. DOI: https://doi.org/10.3390/agriculture13040822.

de Medeiros Silva W.K., de Freitas G.P., Coelho Junior L.M., de Almeida Pinto P.A.L., Abrahão R. (2019). Effects of climate change on sugarcane production in the state of Paraíba (Brazil): a panel data approach (1990-2015). *Climatic Change*, 154(1-2): 195-209. DOI: https://doi.org/10.1007/s10584-019-02424-7.

Devadoss S., Luckstead J. (2010). An analysis of apple supply response. *International Journal of Production Economics*, 124(1): 265-271. DOI: https://doi.org/10.1016/j.ijpe.2009.11.024.

Đokić D., Novaković T., Tekić D., Matkovski B., Zekić S., Milić D. (2022). Technical efficiency of agriculture in the European Union and Western Balkans: SFA method. *Agriculture*, 12(12): 1992. DOI: https://doi.org/10.3390/agriculture12121992.

Doukas Y.E.L., Maravegias N., Chrysomallidis C. (2022). *Digitalization in the EU agricultural sector: Seeking a European policy response*. In Mattas K., Baourakis G., Zopounidis C., Staboulis C. (eds), Food Policy Modelling:

Response to Current Issues (pp. 83-98). Springer, Cham. DOI: https://doi.org/10.1007/978-3-031-08317-4_6.

Ebrahim M.K., Zingsheim O., El-Shourbagy M.N., Moore P.H., Komor E. (1998). Growth and sugar storage in sugarcane grown at temperatures below and above optimum. *Journal of Plant Physiology*, 153(5-6): 593-602. DOI: https://doi.org/10.1016/S0176-1617(98)80209-5.

Edison E., Renate D., Denmar D. (2020). Dynamic supply response: implications for Indonesia soyabean crop. *Dinasti International Journal of Economics, Finance Accounting*, 1(4): 568-580. DOI: https://doi.org/10.38035/dijefa.v1i4.530.

Elnagheeb A.H., Florkowski W.J. (1993). Modeling perennial crop supply: An illustration from the pecan industry. *Journal of Agricultural and Applied Economics*, 25(1): 187-196. DOI: https://doi.org/10.1017/S1074070800018745.

FAO (2019). *The State of the World's Biodiversity for Food and Agriculture*, FAO Commission on Genetic Resources for Food and Agriculture Assessments, Rome. http://www.fao.org/3/CA3129EN/CA3129EN.pdf.

Fligstein N., Calder R. (2015). Architecture of markets. In Scott R.A., Kosslyn S.M., Buchmann M. (eds) *Emerging Trends in the Social and Behavioral Sciences* (pp. 1-14). John Wiley Sons, Inc., Hoboken, NJ, USA. DOI: https://doi.org/10.1002/9781118900772.etrds0014.

Gliessman S. (2021). Transforming the food system: what does it mean? *Agroecology and Sustainable Food Systems*, 45(3): 317-319. DOI: https://doi.org/10.1080/21683565.2021.1842303.

Gohain N. (2018). An analysis of problems and constraints faced by farmers in marketing of agricultural produce in Punjab. *Economic Affairs*, 63(3). https://doi.org/10.30954/0424-2513.3.2018.11

Haile M.G., Kalkuhl M., Von Braun J. (2016). Worldwide acreage and yield response to international price change and volatility: a dynamic panel data analysis for wheat, rice, corn, and soybeans. *American Journal of Agricultural Economics*, 98(1): 172-190. DOI: https://doi.org/10.1093/ajae/aav013

Hannay J.W., Payne B.K. (2022). Effects of aggregation on implicit bias measurement. *Journal of Experimental Social Psychology*, 101, 104331. DOI: https://doi.org/10.1016/j.jesp.2022.104331

Hazrana J., Kishore A., Roy D. (2020). Supply response of staple food crops in the presence of policy distortions: some evidence from India. *Agricultural Applied Economics Association Annual Meeting*, Kansas City, MO, 1-25.

He L., Jin N., Yu Q. (2020). Impacts of climate change and crop management practices on soybean phenology changes in China. *Science of the Total Environment*, 707, 135638. DOI: https://doi.org/10.1016/j.scitotenv.2019.135638.

Hertel T.W. (2011). The global supply and demand for agricultural land in 2050: a perfect storm in the making? *American Journal of Agricultural Economics*, 93(2): 259-275. DOI: https://doi.org/10.1093/ajae/aaq189.

Hussain A., Khan A.A. (2021). Wild birds trade in Dera Ismael Khan and Bannu divisions of Khyber PakhtunKhwa (KPK) province, Pakistan. *Brazilian Journal of Biology*, 83. DOI: https://doi.org/10.1590/1519-6984.247915.

Jahangir M.H., Danehkar S. (2022). A comparative drought assessment in Gilan, Iran using Pálfai drought index, de Martonne aridity index, and Pinna combinative index. *Arabian Journal of Geosciences*, 15(1): 90. DOI: https://doi.org/10.1007/s12517-021-09107-7.

Kalaiselvi K., Sujarani P., Sakthivel V. (2024). Cropping pattern in farming. In Kalaiselvi K., Anand A.J., Tanwar P., Raza H. (eds) *Advanced Technologies for Smart Agriculture* (pp. 1-18). River Publishers, Gistrup.

Khan R., Hussain S.M.A. (2007). Farm supply response to price: a case study of sugarcane in Pakistan (1986 -2005). *Journal of Independent Studies and Research*, 5(2).

Khushk A.M., Memon A., Saeed I. (2011). Analysis of sugar industry competitiveness in Pakistan. *Journal of Agriculture Research*, 1(49).

Krishna R. (1963). Farm supply response in India-Pakistan: a case study of the Punjab region. *The Economic Journal*, 73(291): 477. DOI: https://doi.org/10.2307/2228581.

Lavanya B.T., Manjunatha A.V. (2025). Invisible monopsony in Indian sugar sector. *Sugar Tech*, 27(2): 318-327. DOI: https://doi.org/10.1007/s12355-024-01499-6.

Liu X., Lehtonen H., Purola T., Pavlova Y., Rötter R., Palosuo T. (2016). Dynamic economic modelling of crop rotations with farm management practices under future pest pressure. *Agricultural Systems*, 144: 65-76. DOI: https://doi.org/10.1016/j.agsy.2015.12.003.

Lobell D.B., Hammer G.L., McLean G., Messina C., Roberts M.J., Schlenker W. (2013). The critical role of extreme heat for maize production in the United States. *Nature Climate Change*, 3(5): 497-501. DOI: https://doi.org/10.1038/nclimate1832.

Lobell D.B., Roberts M.J., Schlenker W., Braun N., Little B.B., Rejesus R.M., Hammer G.L. (2014). Greater sensitivity to drought accompanies maize yield increase in the U.S. Midwest. *Science*, 344(6183): 516-519. DOI: https://doi.org/10.1126/science.1251423.

Mai C., Lin S. (2021). The effects of uncertainties over R&D policy or market demand on R&D levels. *Managerial and Decision Economics*, 42(4): 1048-1056. DOI: https://doi.org/10.1002/mde.3291.

Mbua I.A., Atta-Aidoo J. (2023). Acreage supply response of sugarcane out-growers in Tanzania: a vector error correction model (VECM) approach. *Cogent Food Agriculture*, 9(1). DOI: https://doi.org/10.1080/23311932.2023.2229575.

Mearns L.O., Rosenweig C., Goldberg R. (1997). Mean and variance change in climate scenarios: Methods, agricultural applications, and measures of uncertainty. *Climate Change*, 35: 367-396. DOI: https://doi.org/10.1023/A:1005358130291.

Mendelsohn B.R., Nordhaus W.D., Shaw D. (1994). The impact of global warming on agriculture: a Ricardian analysis. *The American Economic Review*, 84(4): 753-771. https://www.jstor.org/stable/2118029.

Mivumbi M., Yuan X. (2023). Sustainable environmental economics in farmers' production factors via irrigation resources utilization using technical efficiency and allocative efficiency. *Sustainability*, 15(5), 4101. DOI: https://doi.org/10.3390/su15054101.

Mushtaq K., Dawson P.J. (2002). Acreage response in Pakistan: a co-integration approach. *Agricultural Economics*, 27: 111-121. DOI: https://doi.org/10.1016/S0169-5150(02)00031-2.

Mustafa G., Latif I.A. Egwuma, H. (2016). An empirical analysis of supply response of rubber in Malaysia. *American Journal of Agricultural and Biological Sciences*, 11(4): 148-156. DOI: https://doi.org/10.3844/ajabssp.2016.148.156.

Mustafa Z., Vitali G., Huffaker R., Canavari M. (2024). A systematic review on price volatility in agriculture. *Journal of Economic Surveys*, 38(1): 268-294. DOI: https://doi.org/10.1111/joes.12549.

Nelson G.C., Valin H., Sands R.D., Havlík P., Ahammad H., Deryng D., Elliott J., Fujimori S., Hasegawa T., Heyhoe E., Kyle P., von Lampe M., Lotze-Campen H., d'Croz D.M., van Meijl H., van der Mensbrugghe D., Müller C., Popp A., Robertson R., Robinson S., Schmid E., Schmitz C., Tabeau A., Willenbockel D. (2014). Climate change effects on agriculture: Economic responses to biophysical shocks. *Proceedings of the National Academy of Sciences of the United States of America*, 111(9): 3274-3279. DOI: https://doi.org/10.1073/pnas.1222465110.

Ngoc L.N.B., Thong L.Q., Hoa T.A. (2022). An analysis of supply response of black tiger shrimp production using Nerlove model: a case study of the Vietnamese Mekong delta. In Nguyen A.T., Hens L. (eds) *Global Changes and Sustainable Development in Asian Emerging Market Economies* (Vol. 1, pp. 121-131). Springer, Cham. DOI: https://doi.org/10.1007/978-3-030-81435-9_9

Nkang N.M., Ndifon H.M., Edet E.O. (2007). Maize supply response to changes in real prices in Nigeria: a vector error correction approach. *Agricultural Journal*, 2(3): 419-425.

Nosheen M., Iqbal J. (2008). Acreage response of major crops in Pakistan (1970-71 to 2006-07). *ARPN Journal of Agricultural and Biological Science*, 3(6): 55-64.

Osborne T. (2005). Imperfect competition in agricultural markets: evidence from Ethiopia. *Journal of Development Economics*, 76(2): 405-428. DOI: https://doi.org/10.1016/j.jdeveco.2004.02.002.

Pakistan Sugar Mills Association (2000). *Annual Report 2000*. Islamabad. Retrieved from https://www.psmacentre.com/documents/Annual%20Report%202000.pdf.

Pakistan Sugar Mills Association (2021). *Annual Report 2021*. Islamabad. Retrieved from https://www.psmacentre.com/documents/PSMA%20Annual%20Report%20Final%20%202021.pdf.

Pardey P.G., Beintema N.M., Dehmer S., Wood S. (2006). Agricultural research: A growing global divide? *Food Policy Report No. 17*. International Food Policy Research Institute.

Pirzada A.J., Shahid N., Ghauri R.T. (2023). The ongoing crisis in the sugar industry: The implications of legislations and need of deregulation. *The Pakistan Development Review,* 62(4): 553-572. DOI: https://doi.org/10.30541/v62i4pp.553-572.

Ray D.K., Ramankutty N., Mueller N.D., West P.C., Foley J.A. (2012). Recent patterns of crop yield growth and stagnation. *Nature Communications*, 3(1): 1293. DOI: https://doi.org/10.1038/ncomms2296.

Rezaei E.E., Siebert S., Hüging H., Ewer, F. (2018). Climate change effect on wheat phenology depends on cultivar change. *Scientific Reports*, 8(1): 4891. DOI: https://doi.org/10.1038/s41598-018-23101-2.

Saddiq M., Fayaz M., Hussain Z., Shahab M., Ullah I. (2013). Acreage response of sugarcane to price and non price factors in Khyber Pakhtunkhwa. *International Journal of Food and Agricultural Economics*, 2(3): 121-128. DOI: https://10.22004/ag.econ.186272.

Santeramo F.G., Miljkovic D., Lamonaca E. (2021). Agri-food trade and climate change. *Economia Agro-Alimentare*, 1: 1-18. DOI: https://doi.org/10.3280/ecag1-2021oa11676.

Shafique M., Hussain Z., Sial M. (2007). Supply response function of sugarcane crop in Punjab, Pakistan. *European Journal of Scientific Research*, 17(2): 277-290.

Shehzad M., Zahid N., Maqbool M., Singh A., Liu H., Wu C., Khan A., Wahid F., Saud S. (2022). Climate resilience in agriculture. In Jatoi W.N., Mubeen M., Ahmad A., Cheema M.A., Lin Z., Hashmi M.Z. (eds) *Building Climate Resilience in Agriculture: Theory, Practice and Future Perspective* (pp. 67-82). Springer, Cham. DOI: https://doi.org/10.1007/978-3-030-79408-8_5.

Siegle J., Astill G., Plakias Z., Tregeagle D. (2024). Estimating perennial crop supply response: a methodology literature review. *Agricultural Economics*, 55(2): 159-180. DOI: https://doi.org/10.1111/agec.12812.

Skogstad G. (1993). Policy under siege: supply management in agricultural marketing. *Canadian Public Administration*, 36(1): 1-23.

Tao F., Yokozawa M., Xu Y., Hayashi Y., Zhang Z. (2006). Climate changes and trends in phenology and yields of field crops in China, 1981-2000. *Agricultural and Forest Meteorology*, 138(1-4): 82-92. DOI: https://doi.org/10.1016/j.agrformet.2006.03.014.

Tenaye A. (2020). New evidence using a dynamic panel data approach: cereal supply response in smallholder agriculture in Ethiopia. *Economies*, 8(3): 61. DOI: https://doi.org/10.3390/economies8030061.

Thornton P.K., Ericksen P.J., Herrero M., Challinor A.J. (2014). Climate variability and vulnerability to climate change: a review. *Global Change Biology*, 20(11): 3313-3328. DOI: https://doi.org/10.1111/gcb.12581.

U.S. Department of Agriculture, Foreign Agricultural Service. (2021, April 22). Sugar annual: Pakistan. Islamabad. Report No. PK2021-0006 [GAIN Report]. https://apps.fas.usda.gov/newgainapi/api/Report/DownloadReportByFileName?fileName=Sugar%20Annual_Islamabad_Pakistan_04-15-2021.pdf.

Van Der Wiel K., Bintanja R. (2021). Contribution of climatic changes in mean and variability to monthly temperature and precipitation extremes. *Communications Earth Environment*, 2(1): 1. DOI: https://doi.org/10.1038/s43247-020-00077-4.

Vasantha S., Shekinah D.E., Gupta C., Rakkiyappan P. (2012). Tiller production, regulation and senescence in sugarcane (saccharum species hybrid) genotypes. *Sugar Tech*, 14(2): 156-160. DOI: https://doi.org/10.1007/s12355-011-0129-6.

Verma R.R., Srivastava T.K., Singh P. (2019). Climate change impacts on rainfall and temperature in sugarcane growing Upper Gangetic Plains of India. *Theoretical and Applied Climatology*, 135(1-2): 279-292. DOI: https://doi.org/10.1007/s00704-018-2378-8.

Von Cramon-Taubadel S., Goodwin B.K. (2021). Price transmission in agricultural markets. *Annual Review of Resource Economics*, 13(1): 65-84. DOI: https://doi.org/10.1146/annurev-resource-100518-093938.

Wang Y., Wang J., Wang X. (2020). COVID-19, supply chain disruption and China's hog market: A dynamic analysis. *China Agricultural Economic Review*, 12(3): 427-443. DOI: https://doi.org/10.1108/CAER-04-2020-0053.

Wani M.H., Sehar H., Paul R.K., Kuruvila A., Hussain I. (2015). Supply response of horticultural crops: The case of apple and pear in Jammu & Kashmir. *Agricultural Economics Research Review*, 28(1): 83. DOI: https://doi.org/10.5958/0974-0279.2015.00006.3.

Wasim M.P. (1997). Sugarcane acreage response in Sindh - Pakistan. *Pakistan Journal of Applied Economics*, 2(1): 143-156.

Wu J., Adams R.M. (2002). Micro versus macro acreage response models: does site-specific information matter? *Journal of Agricultural and Resource Economics*, 27(1): 40-60. DOI: https://doi.org/10.22004/ag.econ.31074.

Yaseen M.R., Dronne Y. (2011). Estimating the supply response of main crops in developing countries: the case of Pakistan and India. *ARPN Journal of Agricultural and Biological Science*, 6(10): 78-87.

Yu B., Liu F., You L. (2012). Dynamic agricultural supply response under economic transformation: a case study of Henan, China. *American Journal of Agricultural Economics*, 94(2): 370-376. DOI: https://doi.org/10.1093/ajae/aar114.

Yu C., Miao R., Khanna M. (2021). Maladaptation of U.S. corn and soybeans to a changing climate. *Scientific Reports*, 11(1), 12351. DOI: https://doi.org/10.1038/s41598-021-91192-5.

Yu J., Smith A., Sumner D.A. (2018). Effects of crop insurance premium subsidies on crop acreage. *American Journal of Agricultural Economics*, 100(1): 91-114. DOI: https://doi.org/10.1093/ajae/aax058.

REA | ITALIAN REVIEW OF AGRICULTURAL ECONOMICS

Firenze University Press
www.fupress.com/rea

Research article

Silent salesmen: the past, present and future of vending machines

Alberto Bertossi[1,*], Stefania Troiano[2], Francesco Marangon[2]

[1] *Department of Agrifood, Environmental and Animal Sciences, University of Udine, Italy*
[2] *Department of Economics and Statistics, University of Udine, Italy*
*Corresponding author. E-mail: alberto.bertossi@uniud.it

Abstract. This article presents a historical analysis of the evolution of the vending machine industry and its impact on consumer eating habits in Italy and the United States. Specifically, this paper traces its origins from an initial vision of an automatic age in which machines would replace traditional sales channels to their position as a significant auxiliary service in the present day. The vending industry is now predominantly associated with 'junk food' and impulse purchases, but this work opens new avenues for additional studies and suggests that this narrative is about to change. Driven by greater consumer awareness of issues such as sustainability and well-being, the industry is currently moving towards more social and health-conscious aspects. The integration of technologies such as artificial intelligence and the emergence of micromarkets have the potential to transform machines from 'silent salesmen' into 'smart salesmen'.

Keywords: vending machines, food habits, artificial intelligence, welfare, micromarkets.
JEL codes: L1, L81.

OPEN ACCESS

Citation: Bertossi, A., Troiano, S., & Marangon, F. (2025). Silent salesmen: the past, present and future of vending machines. *Italian Review of Agricultural Economics* 80(3): 103-115. DOI: 10.36253/rea-15997

Received: February 27, 2025

Revised: October 30, 2025

Accepted: October 30, 2025

Data Availability Statement: Data will be made available by the corresponding author upon request.

Competing Interests: The Author(s) declare(s) no conflict of interest.

Guest Editor: Filiberto Altobelli

ORCID
AB: 0000-0002-8590-9621
ST: 0000-0001-6198-5542
FM: 0000-0001-7519-2922

HIGHLIGHTS

- Since their creation, vending machines have been regarded as the future of food retailing.
- Until now, vending machines have never been a viable alternative to food shops, both in United States and Italy.
- Greater focus on welfare, artificial intelligence and micro-markets will transform vending machines from 'silent' to 'smart' salesmen.

1. INTRODUCTION

According to Euromonitor International, the term 'vending' refers to 'the sale of products at an unattended point of sale through a machine operated by introducing coins, bank notes, payment cards, tokens or other means of cashless payment'. Currently, regardless of our location, a vending machine is almost always nearby, ready to satisfy one or more needs. Although buying food from a vending machine is a daily and almost mechanical part of our 'modern' eating behaviours, little is known about vending history, how it has influenced people's food habits and how it is changing. This study contributes to this knowledge gap by offering a historical overview of how the vending industry has evolved from 1900 to the present day, as well as its role in shaping new consumer habits in an increasingly industrialised society.

This paper is based on an analysis of how the vending industry has evolved in two of the most important global markets: the United States and Italy. The choice of these regions is based on source accessibility and a shared history of innovation in this industry. First, automated vending in its present form originated and was initially developed in the United States (Segrave, 2002), thus ensuring a sufficient amount of and access to the market data, industry news and academic literature required to create a comprehensive historical profile. Second, the Italian vending sector has descended from that developed in the United States and shares industrial and sociocultural evolutionary dynamics (Fumi, 2023). Accordingly, a comparison of the two markets facilitates an understanding of the developments that occurred in Italy in the second half of the twentieth century and those to come. Finally, the Italian sector is currently acknowledged as globally significant in terms of its cutting-edge supply chain, which is capable of responding to social changes (Henke, Sardone, 2020).

Published studies regarding the history and evolution of the vending sector are rather fragmented in both the U.S. and Italian contexts. Certainly, the literature on the topic is not extensive. Thus, to augment the existing literature on vending services in the U.S. market (Huppatz, 2022; Palmer, 1983; Rasmussen, 2001; Segrave, 2002; Shocket, 1955), primary sources, namely articles published in *The New York Times*, were consulted to assess the economic and sociocultural impacts that vending machines were having in the United States from 1950 to the early 2000s. Despite its non-scientific nature, *The New York Times* facilitated the creation of a logical thread that united the various themes discussed by the authors cited above. Historical and economic studies are even scarcer for the Italian market. Accordingly, the same approach was adopted to augment the small body of extant literature in Italy (Fontana, 2015; Fumi, 2023; Henke, Sardone, 2020) with data provided by Confida, the Italian vending association. This situation is different from more recent academic studies, particularly on consumer behaviour and the types of foods sold in vending machines. These studies have been used to support the narrative and highlight the current problems facing the vending industry as well as potential future opportunities. In this regard, this paper also compares the two markets on three key issues related to the latter aspect, namely: (1) welfare and environmental sustainability, (2) artificial intelligence (AI) and (3) micro-markets.

As a commercial sector, vending has often attempted to establish itself as a viable alternative to traditional grocery stores but has not yet achieved this goal. This failure is the result of several intersecting technological and sociocultural factors. However, the same factors that once created barriers may now be the driving force behind the sector's evolution towards a truly person- and community-oriented service according to a new narrative aligned with the future.

2. HISTORICAL EVOLUTION OF THE VENDING SECTOR AND CONSUMPTION IN THE UNITED STATES AND ITALY

2.1. The United States

Vending has a history that is older than one might imagine. Heron of Alexandria is credited with the development of the first vending machine, designed around 220 BC, to offer holy water in temples in exchange for a drachma (Henke, Sardone, 2020; Higuchi, 2007; Segrave, 2002). There is no further relevant evidence of the use of vending machines in society between that period and the second half of the nineteenth century, excluding machines that dispensed stamps, postcards and tobacco. In 1888, the (perhaps) first and most famous prototype for offering a food product (TuttiFrutti gum) was patented and presented to the public in 1888 (Fumi, 2023; Higuchi, 2007; Segrave, 2002; Smith, 2006).

1900 to 1940

In the early twentieth century, vending machines quickly became a symbol of what has been called the 'automatic age' (Huppatz, 2022; Rasmussen, 2001) – that is, a 'current of thought' among entrepreneurs who imagined a future of consumption that was totally automated and facilitated without any human intervention. In this view, which was widely supported by the media and the business world of the time, vending machines were proposed as the perfect substitute for traditional groceries and as a means of selling anything anywhere at more affordable prices (Segrave, 2002). This vision spread rapidly in large urban centres due in part to more frequent, intense urbanisation and various sociocultural changes, which saw the birth of a food system geared more towards the production, marketing and consumption of industrial, standardised and high-nutritional-value food (so-called scientific eating; Levenstein, 2003b). The result was the widespread appearance of vending machines in numerous public places (e.g. theatres, bus stops and underground stations) and increasingly varied food offerings (e.g. chocolate, sweets and peanuts; Segrave, 2002). The strong enthusiasm of the time prompted several entrepreneurs to use vending machines to sell more complex foods. One of the most emblematic examples of 'automatic consumption' that emerged at the time was the Philadelphia Automat, a restaurant founded in 1902 and run by Horn & Hardart that combined fast food with vending machines (Diehl, Hardart, 2002; Epple, 2009; Fumi, 2023; Karmarkar, 2021; Segrave, 2002; Smith, 2006). Although it was a replica of a German model and employed human labour behind the scenes (Epple, 2009; Huppatz, 2022; Smith, 2006), the Philadelphia Automat was (perhaps) the first example of vending machines located in private venues and perhaps the first attempt at an automatic restaurant in the United States capable of offering buyers a complete meal (e.g. sandwiches, salads and cakes) rather than prepackaged snacks.

Despite the enthusiasm generated by vending machines and the futuristic visions of the business world, the sector's growth was anything but linear or exponential, at least until the Second World War and the years that followed. In fact, between 1910 and 1940, the vending sector experienced several periods of stagnation alternated with moments of controlled growth; however, it never reached the popularity it had between 1890 and 1910 (Segrave, 2002). This stagnation is attributable to technical issues (e.g. vandalism and malfunction), health-related concerns (i.e. food perishability) and, above all, social attitudes (i.e. consumer resistance to abandoning traditional sales channels). According to Segrave (2002), the idea of 'automatic consumption' clashed with a reality where the only food products that people bought from vending machines were widely known, simple, standardised and purchased impulsively without much thought about sampling them first: sweets, chewing gum and soft drinks. This behaviour was influenced by attitudes towards food linked to tradition, conviviality and fresh food, which viewed fast, industrial 'scientific food' with suspicion or disgust (Levenstein, 2003b). The consequence was the failure of countless attempts to make vending a viable alternative to traditional sales channels and its consolidation as a support service (Segrave, 2002). However, American society was slowly changing, with lifestyles becoming faster-paced and women considered no longer as solely responsible for the home and kitchen; they also started to work in offices or factories (Levenstein, 2003a, 2003b).

1940 to 1970

During and following the Second World War, the vending sector experienced a decisive revival (Fumi, 2023; Segrave, 2002; Shocket, 1955), a revolution that led to an exponential increase in factory work, which required more labourers than during the prewar period (including women), and the establishment of day and night shifts to facilitate uninterrupted production (Shocket, 1955). An emerging challenge was feeding workers at all hours of the day during specific staff shortages. The flexibility of vending machines made them an elegant and practical solution, and the vending industry seized this opportunity to significantly expand its food offerings, such as sandwiches and frozen foods, while improving food quality (Shocket, 1955). In a short time, vending machines became complements and alternatives to the traditional cafés, canteens and grocery stores that served nearby factories (Shocket, 1955), which contributed to and reinforced the concept of 'industrial feeding' and, above all, coffee breaks, which emerged in response to the coffee vending machine in 1947 (New York Times, 1947). The introduction of vending machines also led to an increase in productivity because workers no longer had to leave the factory to go to the nearest café for coffee or lunch, thereby saving precious time (New York Times, 1956). With the introduction of coffee vending machines, the American vending industry entered its 'golden age', with about 2 million vending machines in operation across the country and a turnover of almost $1 billion in 1950 (New York Times, 1950). Although cigarettes were the biggest selling commodity, major future growth was forecast for food and beverages, which initially accounted for just a small share of the market (New York Times, 1950). In fact, according to Shocket (1955), from 1952 to 1955, cigarette sales declined by 11%, while cold and hot cup beverages increased by 4.8% and 6.16%, respectively.

The impact of vending machines on the collective imagination in the 1950s and 1960s was even stronger than it had been half a century earlier, so much so that it revived the old vision advocated by proponents of the 'automatic age' (Huppatz, 2022; Rasmussen, 2001; Segrave, 2002). Indeed, in the United States, at the height of an economic boom and immersed in a consumerist and convenient culture (Levenstein, 2003a), it was common to refer to vending machines as 'monstrous robots' or 'silent salesmen' (Hecht, 1956) capable of replacing traditional figures, such as the milkman (New York Times, 1953), and selling anything and everything at cheaper prices than the traditional market (Rasmussen, 2001). This latter aspect, combined with the machines' versatility and ability to immediately satiate consumers' impulsive buying desires, contributed to their rapid adoption practically everywhere, especially in workplaces (Table 1; New York Times, 1958; Shocket, 1955).

Even with these new trends of consumers increasingly choosing processed and fast foods – favoured by an increasingly industrialised food sector, changes in family dynamics and intense marketing campaigns by food companies (Levenstein, 2003a; Recordati, 2015) – the vending sector never managed to completely convince consumers to rely on vending machines when purchasing foods more complex than simple snacks (Segrave, 2002). In fact, excluding cigarettes, which accounted for just over 40% of sales, approximately $1.6 billion of sales in 1964 was attributed to foods intended for immediate consumption, especially coffee, soft drinks and packaged confections (37.68% of the total). Conversely, more complex foods traditionally consumed as part of a complete meal either at home or in other private locations, such as milk, ice cream and prepared and hot canned foods, constituted a niche market whose sales amounted to approximately $290,000 (8.29% of the total; Table 2; Figure 1). This trend remained virtually unchanged in the subsequent decades, with soft drinks dominating the market (53.98% of sales in 1999; Table 2; Figure 1). In other words, the dream of automatic stores and restaurants never quite materialised, largely because vending machines could not replicate the human shopping experience (Segrave, 2002). Moreover, the industry did not expand into new markets, but rather further penetrated existing ones, particularly factories, public places, universities and offices (Table 1).

1970 to the present

Between the late 1960s and early 2000s, although the vending sector did not undergo major changes concerning the types of food sold and consumed, the perceptions of citizens and the federal government experienced a radical shift. As consumption increased, so did complaints from schools and families about the poor nutritional quality of the foods sold in vending machines, which were considered to be among the primary causes of rampant youth obesity in those years, competing with federal programmes (e.g. the National Lunch School Act) and family nutrition education (New York Times, 1973, 1976; Segrave, 2002). In response, numerous policies were proposed (and sometimes undertaken) to remove (or at least significantly reduce) the presence of such junk food (especially soda and snacks) from vending machines in schools (New York Times, 2001; Salinsky, 2009). One example is the Community Transformation Grants (CTG) programme, created under the Affordable Care Act and funded by the Prevention and Public Health Fund with the aim of intervening systematically (i.e. at the policy and environmental levels) to create new, healthier consumption habits (Lillehoj *et al*., 2015). However, this was met with strong opposition from the beverage industry and, consequently, the vending sector, so much so that vending machines and the ultraprocessed foods they offered were never completely eliminated from schools or healthcare facilities (Byrd-Bredbenner *et al*., 2012; Kann *et al*., 2005; Kibblewithe *et al*., 2010; Lawrence *et al*., 2009; Pasch *et al*., 2011; Salinsky, 2009). The vending industry attempted to meet federal and family demands by increasing the amount of healthy foods and beverages in their machines, but this strategy proved ineffective because of the overwhelming popularity of traditional products compared with the less attractive, less appealing and costlier healthy options (Segrave, 2002). These challenges persist to the present day, and finding effective ways to incentivise the consumption of such products is complex due to psychological factors, sales

Table 1. The evolution of vending sales (in millions of U.S. dollars [$]) in the United States from 1964 to 1999 by location.

Location	1964		1970		1983		1991		1999	
	$ vol	%	$ vol	%	$ vol	%	$ vol	%	$ vol	%
Plant and factories	1,118	*32.00*	2,178	*35.00*	5,410	*36.40*	7,550	*29.00*	6,000	*17.10*
Public locations	1,328	*38.00*	1,618	*26.00*	3,002	*20.20*	6,740	*25.90*	10,000	*28.50*
Primary and secondary schools	n/a	*n/a*	249	*4.00*	624	*4.20*	590	*2.30*	700	*2.00*
Colleges and universities	384	*11.00*	622	*10.00*	1,218	*8.20*	2,400	*9.20*	4,000	*11.40*
Offices	140	*4.00*	435	*7.00*	1,441	*9.70*	5,680	*21.80*	8,500	*24.20*
Hospitals and nursing homes	70	*2.00*	218	*3.5*	802	*5.40*	900	*3.50*	2,400	*6.80*
Government and military	n/a	*n/a*	156	*2.5*	966	*6.50*	1,000	*3.80*	1,350	*3.80*
All other	454	*13.00*	747	*12.00*	1,397	*9.40*	1,139	*4.40*	2,150	*6.10*

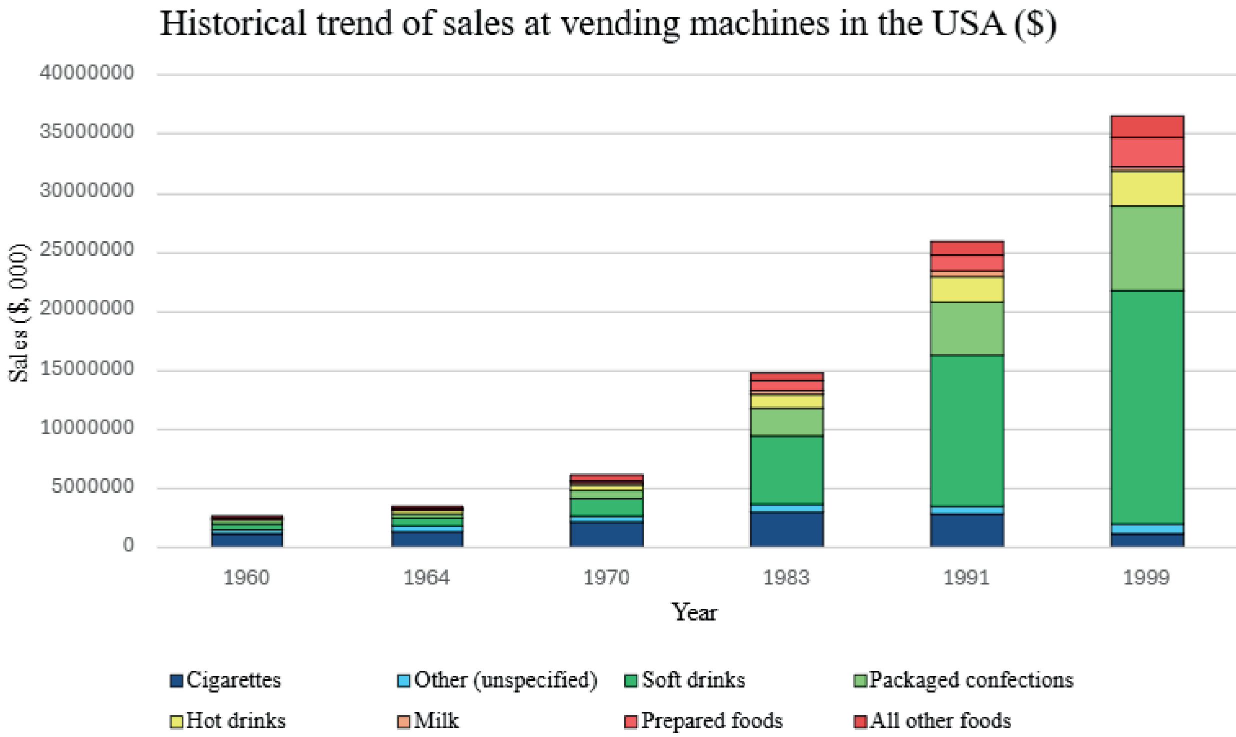
Source: data taken from Segrave (2002).

Table 2. The evolution of vending turnover (in thousands of U.S. dollars [$]) and the number of vending machines in the United States from 1960 to 1999.

Food category	Data	1960		1964		1970		1983		1991		1999	
Packaged confections	Sales volume	304,647	*11.78%*	392,205	*1.22%*	671,314	*10.79%*	2,235,000	*15.04%*	4,561,000	*17.54%*	7,200,000	*19.67%*
	Machines	585,400	*15.58%*	688,110	*16.57%*	843,021	*16.85%*	850,000	*15.11%*	950,000	*15.22%*	1,140,000	*16.17%*
Bulk confections	Sales volume	54,880	*2.12%*	64,922	*1.86%*	305,416	*4.91%*	174,300	*1.17%*	254,579	*0.98%*	347,450	*0.95%*
	Machines	1,120,000	*29.81%*	1,135,000	*27.33%*	1,286,000	*25.70%*	1,400,000	*24.88%*	1,585,500	*25.40%*	2,003,000	*28.41%*
Soft drinks	Sales volume	438,619	*16.96%*	655,646	*18.76%*	1,496,878	*24.05%*	5,967,500	*40.15%*	12,675,000	*48.75%*	19,755,000	*53.98%*
	Machines	947,300	*25.21%*	1,049,900	*25.28%*	1,301,093	*26.01%*	1,910,000	*33.94%*	2,407,000	*38.56%*	3,100,000	*43.97%*
Coffee	Sales volume	142,940	*5.53%*	268,920	*7.70%*	n/a	*n/a*	n/a	*n/a*	n/a	*n/a*	n/a	*n/a*
	Machines	149,800	*3.99%*	199,200	*4.80%*	n/a	*n/a*	n/a	*n/a*	n/a	*n/a*	n/a	*n/a*
Hot drinks (including coffee)	Sales volume	n/a	*n/a*	n/a	*n/a*	451,795	*7.26%*	1,214,000	*8.17%*	2,085,440	*8.02%*	2,910,000	*7.95%*
	Machines	n/a	*n/a*	n/a	*n/a*	245,081	*4.90%*	264,600	*4.70%*	286,000	*4.58%*	320,000	*4.54%*
Ice cream	Sales volume	25,555	*0.99%*	29,694	*0.85%*	50,513	*0.81%*	70,800	*0.48%*	182,582	*0.70%*	470,000	*1.28%*
	Machines	36,500	*0.97%*	42,300	*1.02%*	50,226	*1.00%*	41,000	*0.73%*	47,500	*0.76%*	75,000	*1.06%*
Milk	Sales volume	61,630	*2.38%*	81,900	*2.34%*	152,567	*2.45%*	343,000	*2.31%*	477,000	*1.83%*	408,000	*1.11%*
	Machines	52,500	*1.40%*	63,000	*1.52%*	84,606	*1.69%*	91,500	*1.63%*	94,500	*1.51%*	84,000	*1.19%*
Hot canned foods	Sales volume	22,121	*0.86%*	28,564	*0.82%*	73,678	*1.18%*	144,000	*0.97%*	128,000	*0.49%*	110,600	*0.30%*
	Machines	22,900	*0.61%*	31,300	*0.75%*	45,607	*0.91%*	54,700	*0.97%*	44,000	*0.70%*	28,000	*0.40%*
Prepared foods	Sales volume	n/a	*n/a*	149,700	*4.28%*	223,923	*3.60%*	812,000	*5.46%*	1,376,000	*5.29%*	2,520,000	*6.89%*
	Machines	n/a	*n/a*	67,150	*1.62%*	66,525	*1.33%*	102,850	*1.83%*	118,000	*1.89%*	150,000	*2.13%*
Pastries	Sales volume	n/a	*n/a*	n/a	*n/a*	79,679	*1.28%*	289,000	*1.94%*	322,450	*1.24%*	210,000	*0.57%*
	Machines	n/a	*n/a*	n/a	*n/a*	78,096	*1.56%*	90,500	*1.61%*	78,000	*1.25%*	48,000	*0.68%*
Juice	Sales volume	n/a	*n/a*	n/a	*n/a*	n/a	*n/a*	n/a	*n/a*	361,700	*1.39%*	668,600	*1.83%*
	Machines	n/a	*n/a*	n/a	*n/a*	n/a	*n/a*	n/a	*n/a*	72,000	*1.15%*	103,000	*1.46%*
Total (foods and beverages)	Sales volume	1,050,392		1,671,551		3,505,763		11,249,600		13,486,672		34,599,650	
	Machines	2,914,400		3,275,960		4,000,255		4,805,150		5,682,500		7,051,000	
Other (cigarettes)	Sales volume	1,141,920	*44.16%*	1,399,780	*40.05%*	2,116,506	*34.01%*	2,926,000	*19.69%*	2,882,000	*11.09%*	1,200,000	*3.28%*
	Machines	793,000	*21.10%*	883,700	*21.28%*	946,030	*18.91%*	785,000	*13.95%*	560,000	*8.97%*	n/a	*n/a*
Other (cigars)	Sales volume	8,785	*0.34%*	12,348	*0.35%*	18,208	*0.29%*	21,500	*0.14%*	n/a	*n/a*	n/a	*n/a*
	Machines	50,200	*1.34%*	59,800	*1.44%*	56,900	*1.14%*	37,000	*0.66%*	n/a	*n/a*	n/a	*n/a*
Other (unspecified)	Sales volume	385,000	*14.89%*	411,000	*11.76%*	582,531	*9.36%*	664,500	*4.47%*	692,750	*2.66%*	800,450	*2.19%*
	Machines	n/a	*n/a*	n/a	*n/a*	n/a	*n/a*	n/a	*n/a*	n/a	*n/a*	n/a	*n/a*
Total (foods, beverages and all others)	Sales volume	2,586,097	*100.00%*	3,494,679	*100.00%*	6,223,008	*100.00%*	14,861,600	*100.00%*	25,998,501	*100.00%*	36,600,100	*100.00%*
	Machines	3,757,600	*100.00%*	4,152,310	*100.00%*	5,003,185	*100.00%*	5,627,150	*100.00%*	6,242,500	*100.00%*	7,051,000	*100.00%*

Note: The percentage values are relative to total products sold, including cigarettes.
Source: data taken from Segrave (2002).

Figure 1. The evolution of vending turnover (in thousands of U.S. dollars [$]) in the United States from 1960 to 1999.



Source: adapted from data provided by Segrave (2002).

locations, marketing techniques and the fact that vending machine purchases have always been based almost entirely on instinct and impulsive needs (Bertossi, 2024; Fiske *et al*., 2004; French *et al*., 1997, 2001; Gorton *et al*., 2010; Hoerr *et al*., 1993; Kocken *et al*., 2012).

2.2. A quick look into the future in the United States

Attention to well-being and environmental sustainability

Although, in the past, the U.S. vending industry has often been trapped in the image of a channel for high-calorie snacks, with public policies that have not always been consistent and market resistance that has hampered its results, this stalemate appears to be nearing an end. Indeed, the literature offers several examples of proactive and fruitful collaborations in making vending a means for consumers to eat properly (Bertossi, 2024). For example, a study conducted in Los Angeles County evaluated the impact of a vending machine policy requiring 100% of products to meet healthy nutrition standards (Wickramasekaran *et al*., 2018). Following implementation of the policy, the average number of calories and sodium and sugar contents per snack purchased decreased by approximately 39%, 30%, and over 50%, respectively. For beverages, the average number of calories and sugar content decreased by 90%, and the sodium content decreased by 25%. Despite these nutritional improvements, the average revenue per vending machine declined by 37% for snacks and 34% for beverages. The authors concluded that while 100% healthy vending policies can substantially improve the nutritional quality of products sold, it is important to anticipate and plan for potential short-term revenue losses during implementation. Viana *et al.* (2018) adopted a similar approach combined with other types of intervention, such as clearer labelling and price increases for unhealthy foods. The results are comparable to those of Wickramasekaran *et al.* (2018), but with the difference that, in the case of Viana *et al.* (2018), this strategy allowed turnover to be maintained.

There is also a growing commitment from an environmental impact perspective. For example, companies such as Coca-Cola, PepsiCo and Mars are leading the transformation of food products sold through vending machines in the United States. The primary focus is on packaging circularity. Coca-Cola, with its 'World Without Waste' strategy (Coca-Cola Company, 2025), is increasing the use of recycled polyethylene terephthalate (rPET) bottles and has made Sprite bottles transparent to facilitate recycling. The goal is to collect and recycle a volume of packaging equivalent to that sold by 2030. PepsiCo, through its 'pep+' programme (PepsiCo, 2025), is focusing on reducing greenhouse gas emissions in its value chain by 40% by 2030, promoting the use of ingredients produced through sustainable agriculture and increasing the recycled content in snack and beverage packaging. Finally, Mars, by investing in its supply chain, integrates sustainable agriculture, which is crucial for ingredients such as cocoa, and ensures that the production of its snacks is powered by renewable energy, reducing the carbon footprint of the final products (Mars, 2025). These initiatives aim to meet growing consumer demand for more responsible choices and will be enhanced by AI.

Artificial Intelligence

Alongside sustainability, AI is becoming crucial across retail, especially vending, given its unique relationship with machines, supporting their evolution and encouraging progress. The industry has never looked back with nostalgia and has always turned towards the future, carefully following societal changes and adapting accordingly. For example, the industry has moved from mechanical to electronic systems, from mechanical keys to touchscreens and from coins to keys and modern apps. Until recently, however, vending has been rather static, anonymous and 'one-way'. In other words, machines and consumers have not engaged in real interactions, an 'exchanges of views' or negotiated offers customised to the buyer's needs in the moment. AI will be able to do this and is expected to completely change the sales and consumption experience, thereby realising the dream of the Automatic Age that began in the 1920s and 1930s. In this way, vending machines will be more human than they have ever been, able to accomplish the following tasks: (1) actively interact with people by responding to their requests for clarification about the characteristics of a product (e.g. the protein content, origin of the food or environmental impact); (2) understand what shoppers need at a certain time of day (e.g. an energetic coffee in the morning); and (3) adapt the offer according to their emotional state (e.g. a hot chocolate or a sweet snack to lift their spirits), their lifestyle (e.g. a protein snack following a workout) or the presence of intolerances (e.g. gluten-free foods for those with coeliac disease). Retailers will transition from simple, anonymous, 'silent' salesmen to 'smart' salesmen able to assist us in our daily lives. Consumers, for their part, will be able to leave feedback on the vending machines' performance so that the machine can learn and ensure the provision of high-quality service that meets the expectations of subsequent consumers.

The emergence of micromarkets

Automatic 24-hour shops (micromarkets) belong to the so-called public vending category and are intended to function as fully automatic neighbourhood shops that are open 24 hours a day. The machines take on a hybrid format that blends the benefits of an automatic bar and a small market by providing snacks, water and classic hot and cold drinks alongside ready-made meals and fresh products. In the United States, this category is recognised in the Food and Drug Administration (FDA) Food Code and supported by guidelines and regulatory clarifications promoted by the industry association. According to the National Automatic Merchandising Association (2024), in 2023 the convenience services sector (which also includes vending machines) reached $26.6 billion, with micromarkets accounting for about one-fifth ($5.4 billion; 20%), making them the main driver of growth in the sector. Within a few years, the number of active locations has grown from ~23,700 (2017) to ~42,900 (2023), reaching ~55,770 in 2024, driven by offices, manufacturing, campuses and healthcare. For the end user, this means more visible assortment, access to fresh/ready-to-eat food and a more informed and faster shopping experience, which explains why micromarkets are gaining ground even over traditional vending. These micromarkets, however, will differ from traditional points of sale not only because they are completely automated, but also because AI enhancements will permit them to adapt their offers in ways that entice consumers to enter by choice rather than because of a lack of alternatives. In other words, micromarkets represent an evolution of the old automats dreamed of by Americans in New York and Philadelphia in the early twentieth century.

2.3. Italy

During the American 'Renaissance' (1950s–60s), the concept of automatic distribution was exported to other regions, including Japan (Higuchi, 2007) and Europe. Because of the First and Second World Wars in the first half of the century, the European vending industry could not progress and develop as it did in the United States. Moreover, in the early postwar period, a specialised organisation of the sector was absent, as was a 'food culture' that favoured the use of technological devices for purchasing food (New York Times, 1962). Nevertheless, the Italian market developed because of its close commercial relationship with the U.S. market, especially with big food and beverage companies, such as Coca-Cola (Fumi, 2023). The first vending machines for cold drinks appeared in the 1950s, although they were confined to industrial workplaces (Fumi, 2023).

The real birth of the Italian vending industry took place in the early 1960s (Fumi, 2023). This decade was marked by the invention of the E61 vending machine, which was capable of serving one of the most important and well-known symbols of Made in Italy in the world: espresso coffee (Fontana, 2015). Similarly to what had occurred in the United States a few years earlier, this helped the industry revolutionise the concept of the coffee break in the workplace, thanks also to the cultural movement and trade union protests of 1968 (Fontana, 2015). Precisely for this reason, over the next 40 years, much attention was paid to designing refreshment areas that made the coffee break even more enjoyable (Fontana, 2015). In 1968, the first completely Italian snack vending machine was invented in response to a market characterised by new consumption trends and habits. While Italy had been synonymous with the 'Mediterranean diet' a few years earlier, American culinary hallmarks such as fast food, sugary drinks and prepackaged foods were increasingly imported from the 1960s through the 1980s (Fumi, 2023; Porru, 2017). Just like all industrialised countries, Italy underwent a profound, although slow, culinary and dietary transformation during those years, defined by the following processes: (1) de-concentration (i.e. replacement of full meals with frequent snacks throughout the day), (2) de-scheduling (i.e. widening of the time slot for meal consumption), (3) de-synchronisation (i.e. non-alignment of mealtimes with those of other members of a group, reducing opportunities for meeting and exchanges), (4) de-localisation (i.e. consumption of a meal no longer in a precise room, but where it happens) and (5) de-ritualisation (i.e. reduction of the traditional rules governing a full meal; Porru, 2017). Although this cultural transformation had the potential to accelerate the sector's development, it did not spread rapidly, and many people remained attached to consuming traditional fresh meals in company, rather than eating industrial meals alone (Fumi, 2023). Much like in the United States, the vending sector failed to establish itself as a valid alternative to traditional food sales and consumption channels, eventually becoming classified as an ancillary sector useful more during a quick break than as a replacement for a complete meal. In 1975, as Fumi (2023) described, only 12,500 vending machines (4.9%) sold snacks or meals, while there are no data regarding the sale of canned food. Conversely, the consumption of coffee and cold drinks was significant, with 157,000 vending machines serving the former (61.4%) and 86,000 serving the latter (33.7%). The development of the vending sector certainly was (and continues to be) driven above all by the coffee culture created during the economic boom (Fumi, 2023).

Although the sector in Italy lagged behind its American counterpart, it experienced constant growth in the following decades and reached an annual turnover of €350 million in 1999 (Vending Magazine, 2013) and the consolidation of Made in Italy on a global level. Today, Italy boasts the most extensive vending machine network in Europe, with 831,000 vending machines scattered throughout the country, followed by France (633,000), Germany (617,000) and England (405,000; Confida, 2024a). By 2023, consumption in both public and private places was close to 4 billion (€1.6 billion), of which 66% was coffee, 18% cold drinks, 16% snacks and the remaining 0.07% ice cream (Confida, 2024a). Turnover in public places alone (i.e. hotels, transport networks, recreational centres and shopping centres/malls), however, amounted to €505 million (Table 3). In this regard, Italy is the only European country whose turnover is derived primarily from the sale of cold drinks (63.6%); in other countries, sales tend to be more balanced among the various product categories (Table 3).

These figures represent only the tip of the iceberg of a larger, more complex sector that operates mainly in the backwaters. Henke, Sardone (2020) identified six key players that constitute the vending sector's supply chain: (1) the reference market (i.e. public and private places that, through contracts or tenders, determine the type of supply, sales prices and service arrangements); (2) vending managers (i.e. the more than 3,000 companies that deal with the vending service in the reference market, optimising processes and maintaining the quality of the food supply); (3) vending machine manufacturers (companies that deal with the construction and sale/rental of the electronic and mechanical end units dedicated to the distribution of food and beverages); (4) food and beverage producers (food companies dedicated to the production of foodstuffs suitable for sale through vending machines); (5) wholesalers; and (6) companies for services. The design and construction of vending machines further exemplify Italian excellence, and almost 70% of this production is exported abroad, representing Made in Italy at a global level (Henke, Sardone, 2020).

2.4. A quick look into the future in Italy

The importance of the Italian market is not only measured in turnover and consumption. Since 1998,

Table 3. Food and beverage vending valuec in 2023 in the United States, Europe and five of the most important European countries.

Geography	Category	Million of euros	%
Europe	Total	4.440	*100*
	Hot drinks	1.250	*28.2*
	Soft drinks	1.601	*36.1*
	Foods	1.588	*35.8*
United Kingdom	Total	543	*100*
	Hot drinks	134	*24.7*
	Soft drinks	198	*36.5*
	Foods	211	*38.9*
France	Total	539	*100*
	Hot drinks	174	*32.3*
	Soft drinks	148	*27.5*
	Foods	217	*40.3*
Italy	Total	506	*100*
	Hot drinks	31	*6.1*
	Soft drinks	322	*63.6*
	Foods	153	*30.2*
Spain	Total	543	*100*
	Hot drinks	134	*24.7*
	Soft drinks	198	*36.5*
	Foods	211	*38.9*
Germany	Total	385	*100*
	Hot drinks	98	*25.5*
	Soft drinks	123	*31.9*
	Foods	164	*42.6*

Note: Sales considered at the end price to the consumer (sales taxes and inflation excluded) in public and semicaptive environments only (i.e. hotels, transport networks, recreational centres and shopping centres/malls).
Source: Euromonitor International.

Italy has hosted one of the most important international vending events: VendItalia. At this expo, exhibitors from all over the world preview their products and innovative technologies. VendItalia – through an increasing number of debates, international talk shows and panels on hot market topics – serves as a benchmark for the global industry. At the most recent event, held in Milan in 2024, three trending topics were discussed widely, which suggests their importance in creating and satisfying new consumer habits: welfare and sustainability, AI and 24-hour automated shops.

Attention to well-being and environmental sustainability

Echoing evidence from the United States on healthier vending policies, the Italian trajectory operationalises 'assisted choice' through labelled assortments and price/placement nudges. Examples of such initiatives in Italy include 'Fresco benessere', 'Percorso salute' and 'Vending Zone', all of which offer shoppers a selection of healthy, fresh products and communicate their characteristics through labels and advertising (Henke, Sardone, 2020). Careful strategic planning is required to support these efforts. According to Perfetti *et al.* (2025), placing such products in the top rows or on the right side increases the likelihood that consumers will see and, therefore, choose them. Setting an appropriate price and working on their familiarity among consumers are also important (Perfetti *et al.*, 2025). The sector is increasingly embracing environmental sustainability as part of a holistic approach to welfare. Indeed, initiatives aimed at promoting local products or those obtained through short supply chains are increasingly common and include 'Clementime' (Henke, Sardone, 2020), 'Consumi o scegli?' (Confida, 2024b), 'Pausa consapevole' (Confida, 2024c), 'Squisit' (Bertossi *et al.*, 2023; Confida, 2024d) and 'EquoSolDA' (Confida, 2025).

Artificial Intelligence

In Italian vending machines, AI is beginning to affect the quality of breaks. A prime example is the mOphas management system developed by Alturas Sistemi, which uses image recognition and telemetry to 'see' what is actually in the vending machine, report when items are out of stock, align prices and layouts, and remotely check supplies. For users, this translates into fewer empty shelves, correct prices and more relevant promotions – that is, a more timely and predictable service. SECO – Clea Vend responds to the same service logic through real-time monitoring with automatic alerts and predictive functions, which reduce machine downtime and guarantee the continuous availability of the desired product, ensuring a smooth user experience even during peak times. Finally, on the interaction front, the Breasy app from Newis/Evoca integrates voice commands that allow users to select and pay from their phone without touching the vending machine, which is useful for hygiene and accessibility. In short, these applications move AI from 'behind the scenes' to perceived benefits: availability, simplicity and trust throughout a break.

The emergence of micromarkets

Following consolidation in the United States, adoption has also accelerated in Europe, with more than 10,000 points located across the various member states in 2024 (a 38% increase compared with 2023; European

Vending & Coffee Service Association, 2024). Of these 10,000 points, almost 3,000 were located in Italy. This expansion is attributable to changes in people's lifestyles and consumption methods, with more and more meals consumed outside the home and less time spent between one meal and the next. This has introduced the need for quick access to fresh food that is ready for consumption during times when traditional shops are closed. This new market segment requires high standards of quality management to ensure that the service meets consumer expectations. For this reason, in 2024 Confida presented its 'Top Quality 24-hour Automatic Shops Protocol', which requires compliance with the regulatory prerequisites governing the sector, in addition to requirements relating to hygiene, food safety, customer care, point of sale security and sustainability (Confida, 2024e). Attention to these aspects is essential in this regard, as it allows for the continuous provision of a high-quality service, avoiding the historical problems that have characterised the sector in the past century, including 'food perishability' and 'malfunctions'.

3. CONCLUSIONS

The evolution of the vending machine industry offers fascinating insights that go beyond its simple history. Vending machines have long been silent salesmen, unable to establish themselves as a complete alternative to traditional sales channels despite their potential to fulfil the futuristic visions that originated during the automatic age. This failure not only highlights historical technical problems and limited market demand, but also profound social and psychological dynamics related to consumption. The act of purchasing food from a machine was perceived as impulsive and impersonal, an act that lacked the conscious choice, social interaction and familiarity that characterises traditional dining or food shopping.

Today, the vending industry's narrative is in flux and provides a starting point from which future studies might explore pathways to evolution. The forces that limited the industry in the past – speed, convenience and automation – may now become its greatest strengths. As the industry focuses on well-being and sustainability, combined with technological innovations such as AI, it has the potential to redefine the role of vending in society. How will the perception of the silent salesman change when it becomes a smart salesman capable of interacting with customers, suggesting products based on their preferences and even measuring their mood? Vending machines might transform from simple dispensers into personal nutrition and well-being assistants integrated within an ecosystem that supports more conscious consumption. This could be particularly relevant in highly industrialised societies such as the United States and Italy, where we often see a food paradox, with people having unlimited access to healthy food but less and less time to cook a full meal or enjoy it with company. Furthermore, the spread of micromarkets, which combine the convenience of vending with the fresh and healthy products offered in traditional markets, suggests that the sector is finally finding a way to overcome its historical limitations. More specifically, micromarkets could play a key role in providing access to more traditional and local foods in rural areas, avoiding the need to travel to urban centres and contributing to the creation of shorter supply chains with a reduced environmental impact.

This study serves as a basis for future research focused not only on sales data, but also on the psychological and social impact of this new 'automatic era'. Future investigations might explore how AI personalisation influences consumers' purchasing decisions or whether the presence of micromarkets in urban contexts impacts eating habits and the local sense of community. Another promising area of research concerns the potential for the vending industry to combat food poverty. Vending machines have the potential to become a vital channel for introducing healthy, affordable food to remote areas or neighbourhoods considered 'food deserts' or 'food swamps': areas without access to supermarkets that sell fresh produce. In an era during which food security has become a global priority, vending might play a significant role in ensuring equitable access to quality food. To realise this potential, industry and public policy must work synergistically to overcome the obstacles that have historically prevented the vending of more complex foods, such as perishability and a lack of commercial appeal, compared with traditional snacks. Structured interventions are essential to encourage the choice of healthy and sustainable products by making them more accessible and affordable. Analysing vending as a social laboratory to understand the evolution of our relationship with food, technology and the environment will open up new avenues for research and reveal a sector that, after a century of attempts, may finally be ready to rewrite its history.

AUTHOR CONTRIBUTIONS

A.B.: Conceptualization, Formal analysis, Writing-Original draft preparation.

S.T.: Writing –Review & Editing.
F.M.: Supervision.

REFERENCES

Bertossi A., Marangon F., Troiano S. (2023). Financing for sustainable food systems: the role of the vending sector. *Economia Agro-alimentare*, 25(2): 115-134. DOI: https://doi.org/10.3280/ecag2023oa14828.

Bertossi A. (2024). Pathways towards food sector sustainability: the case of vending. *Agricultural and Food Economics*, 12(1): 13. DOI 10.1186/s40100-024-00305-x.

Byrd-Bredbenner C., Johnson M., Quick V.M., Walsh J., Greene G.W., Hoerr S., Colby S.M., Kattelmann K.K., Phillips B.W., Kidd T., Horacek T.M. (2012). Sweet and salty. An assessment of the snacks and beverages sold in vending machines on US post-secondary institution campuses. *Appetite*, 58(3): 1143-1151. DOI: https://doi.org/10.1016/j.appet.2012.02.055.

Coca-Cola Company (2025). *Sustainable packaging: world without waste*. https://www.coca-cola.com/it/it/sustainability/sustainable-packaging.

Confida (2024a). *Dati di settore*. https://www.confida.com/dati-di-settore/

Confida (2024b). *Consumi o scegli*. https://www.confida.com/progetti-soci/consumi-o-scegli/

Confida (2024c). *La pausa consapevole*. https://www.confida.com/progetti-soci/la-pausa-consapevole/

Confida (2024d). *Merenda friulana*. https://www.confida.com/progetti-soci/merenda-friulana/

Confida (2024e). *Negozi automatici H24*. http://www.negoziautomaticih24.it/

Confida (2025). *EquosolDA – la pausa caffè equo e solidale*. https://www.confida.com/progetti-soci/equosolda/

Diehl L., Hardart M. (2002). *The Automat: The History, Recipes, and Allure of Horn & Hardart's Masterpiece*. Clarkson Potter, New York.

Epple A. (2009). The "Automat". A history of technological transfer and the process of global standardization in modern fast food around 1900. *Food and History*, 7(2): 97-118. DOI: https://doi.org/10.1484/J.FOOD.1.100652.

European Vending & Coffee Service Association (2024). *EVA publishes its new market report on vending & OCS*. https://www.vending-europe.eu/eva-publishes-its-new-market-report-on-vending-ocs/

Fiske A., Cullen K.W. (2004). Effects of promotional materials on vending sales of low-fat items in teachers' lounges. *Journal of the American Dietetic Association*, 104(1): 90-93. DOI: https://doi.org/10.1016/j.jada.2003.10.011

Fontana A. (2015). Mezzo secolo di vending: storia della distribuzione italiana dal 1963 al 2013. *AIS/Design Journal: Storia e Ricerche*, 3(5): 110-131.

French S.A., Jeffery R.W., Story M., Breitlow K.K., Baxter J.S., Hannan P., Snyder M.P. (2001). Pricing and promotion effects on low-fat vending snack purchases: the CHIPS Study. *American Journal of Public Health*, 91(1): 112. DOI: https://doi.org/10.2105/ajph.91.1.112.

French S.A., Jeffery R.W., Story M., Hannan P., Snyder M.P. (1997). A pricing strategy to promote low-fat snack choices through vending machines. *American Journal of Public Health*, 87(5): 849-851. DOI: https://doi.org/10.2105/AJPH.87.5.849.

Fumi G. (2023). The coin-operated food selling and the machine-vending industry in 20th-century Italy. In d'Errico R., Magagnoli S., Scholliers P., Atkins P.J. (eds) *Eating on the Move from the Eighteenth Century to the Present* (pp. 92-107). Routledge, London. DOI: https://doi.org/10.4324/9781003327820.

Gorton D., Carter J., Cvjetan B., Ni Mhurchu C. (2010). Healthier vending machines in workplaces: both possible and effective. *The New Zealand Medical Journal*, 123(1311): 43-52.

Hecht A. (1956). Robots ... at your service. *The American Mercury*. https://www.unz.com/print/AmMercury-1956nov-00051/

Henke R., Sardone R. (2020). Innovation in the Italian sector of vending machines. Between growth and search for sustainability. *Italian Review of Agricultural Economics*, 75(2): 13-23. DOI: https://doi.org/10.13128/rea-12067.

Higuchi Y. (2007). History of the development of beverage vending machine technology in Japan. *National Museum of Nature and Science: Survey Reports on the Systemization of Technologies*, 7(2): 1-69.

Hoerr S.M., Louden V.A. (1993). Can nutrition information increase sales of healthful vended snacks? *Journal of School Health*, 63(9): 386-390. DOI: https://doi.org/10.1111/j.1746-1561.1993.tb06167.x.

Huppatz D.J. (2022). Robot salesmen: automated food retailing in the United States, 1925-39. *History of Retailing and Consumption*, 7(3): 261-276. DOI: https://doi.org/10.1080/2373518X.2022.2044196.

Kann L., Grunbaum J., McKenna M.L., Wechsler H., Galuska D.A. (2005). Competitive foods and beverages available for purchase in secondary schools-selected sites, United States, 2004. *Journal of School Health*, 75(10): 370-374. DOI: https://doi.org/10.1111/j.1746-1561.2005.00058.x.

Karmarkar U. (2021). Service industrialization, convergence, and digital transformation–II. *Management and Business Review*, 1(3): 42-52. DOI: https://doi.org/10.1177/2694105820210103005.

Kibblewhite S., Bowker S., Jenkins H.R. (2010). Vending machines in hospitals–are they healthy? *Nutrition & Food Science*, 40(1): 26-28. DOI: https://doi.org/10.1108/00346651011015881.

Kocken P.L., Eeuwijk J., Van Kesteren N.M., Dusseldorp E., Buijs G., Bassa-Dafesh Z., Snel J. (2012). Promoting the purchase of low-calorie foods from school vending machines: a cluster-randomized controlled study. *Journal of School Health*, 82(3): 115-122. DOI: https://doi.org/10.1111/j.1746-1561.2011.00674.x.

Lawrence S., Boyle M., Craypo L., Samuels S. (2009). The food and beverage vending environment in health care facilities participating in the healthy eating, active communities program. *Pediatrics*, 123(Supplement_5): S287-S292. DOI: https://doi.org/10.1542/peds.2008-2780G.

Levenstein H. (2003a). *Revolution at the Table: The Transformation of the American Diet*. University of California Press, Oakland, CA, USA.

Levenstein H. (2003b). *Paradox of Plenty: A Social History of Eating in Modern America*. University of California Press, Oakland, CA, USA.

Lillehoj C.J., Nothwehr F., Shipley K., Voss C. (2015). Vending assessment and program implementation in four Iowa worksites. *Health Promotion Practice*, 16(6): 814-825.

Mars (2025). *Net Zero Roadmap*. https://www.mars.com/sites/g/files/dfsbuz106/files/2023-09/Mars%20Net%20Zero%20Roadmap%202050_2.pdf.

National Automatic Merchandising Association (2024). *The State of Convenience Services: A 2022-2023 Industry Census*. https://namanow.org/wp-content/uploads/NAMA-Census-FINAL.pdf.

New York Times (1947). *Machine to serve hot coffee shown*. https://www.nytimes.com/1947/09/25/archives/machine-to-serve-hot-coffee-shown-developed-by-ruddmelikian-big.html.

New York Times (1950). *Coin in the slot: new vending machines are harvesting millions, and the end is not yet*. https://www.nytimes.com/1950/12/03/archives/签cointheslot-new-vending-machines-are-harvesting-millionsand-the.html.

New York Times (1953). *Even the milkman is automatic now*. https://www.nytimes.com/1953/02/06/archives/even-the-milkman-is-automatic-now-devices-selling-quart-cartons-at.html.

New York Times (1956). *Machines shrink the coffee break*. https://www.nytimes.com/1956/11/23/archives/machines-shrink-the-coffee-break-make-a-brew-more-palatable-to-boss.html.

New York Times (1958). *Vending machine hot as a seller*. https://www.nytimes.com/1958/01/06/archives/vending-machine-hot-as-a-seller-industry-tops-2-billion-for-the.html.

New York Times (1962). *U.S. Vending Machines Go Abroad*.

New York Times (1973). *School vending machines assailed for junk food*. https://www.nytimes.com/1973/04/18/archives/school-vending-machines-assailed-for-junk-food-nutrition-seen.html.

New York Times (1976). *Parents Close Tap on Sodas In Westchester School Menu*. https://www.nytimes.com/1976/02/03/archives/parents-close-tap-on-sodas-in-westchester-school-menu.html.

New York Times (2001). *States Try to Limit Sales of Junk Food In School Buildings*. https://www.nytimes.com/2001/09/09/business/states-try-to-limit-sales-of-junk-food-in-school-buildings.html.

Palmer J. (1983). Automatic food service: the meal of the future? *Cornell Hotel and Restaurant Administration Quarterly*, 24(1): 63-70: DOI: https://doi.org/10.1177/001088048302400111.

Pasch K.E., Lytle L.A., Samuelson A.C., Farbakhsh K., Kubik M.Y., Patnode C.D. (2011). Are school vending machines loaded with calories and fat: an assessment of 106 middle and high schools. *Journal of School Health*, 81(4): 212-218. DOI: https://doi.org/10.1111/j.1746-1561.2010.00581.x.

PepsiCo (2025). *Pepsico Positive*. https://www.pepsico.com/pepsico-positive.

Perfetti A., Pietrini R., Scarpi D., Gistri G. (2025). Snack dilemma: how vending machines influence choice of virtue and vice foods. *Journal of Retailing and Consumer Services*, 87, 104369. DOI: https://doi.org/10.1016/j.jretconser.2025.104369.

Porru E. (2017). *Come cambiano le abitudini alimentari: cibo e processi di trasformazione socioeconomica*. https://iris.uniss.it/handle/11388/250258.

Rasmussen C. (2001) Jobs galore for robots, rethinking history. *The Journal of Theory and Practice*, 5(1): 149-162. DOI: https://doi.org/10.1080/13642520010024217.

Recordati G.B.P. (2015). *The food industry: history, evolution and current trends*. https://tesi.luiss.it/15698/1/177941.pdf.

Salinsky E. (2009). *Got Junk? The Federal Role in Regulating "Competitive" Foods*, Issues Brief, No. 835, National Health Policy Forum, Washington, D.C., USA.

Segrave K. (2002) *Vending Machines: An American Social History.* McFarland, Jefferson, NC, USA.

Smith A.F. (2006). *Encyclopedia of Junk Food and Fast Food*. Greenwood, Westport, CT, USA.
Shocket M.G. (1955). *Vending machines*. Doctoral dissertation, Boston University, https://open.bu.edu/bitstream/handle/2144/8106/Shocket_Murray_1957_web.pdf?sequence=1.
Vending Magazine (2013). *Stabili i ricavi delle TOP 100 del vending italiano nel 2013*. https://www.leanus.it/wp-content/uploads/2020/12/Top-100-vending-magazine_DIC_2014.pdf.
Viana J., Leonard S.A., Kitay B., Ansel D., Angelis P., Slusser W. (2018). Healthier vending machines in a university setting: effective and financially sustainable. *Appetite*, 121: 263-267. DOI: https://doi.org/10.1016/j.appet.2017.11.094.
Wickramasekaran R.N., Robles B., Dewey G., Kuo T. (2018). Evaluating the potential health and revenue outcomes of a 100% healthy vending machine nutrition policy at a large agency in Los Angeles County, 2013-2015. *Journal of Public Health Management and Practice*, 24(3): 215-224. DOI: https://doi.org/10.1097/PHH.0000000000000702.

REA | ITALIAN REVIEW OF AGRICULTURAL ECONOMICS

Firenze University Press
www.fupress.com/rea

Research article

What is driving the performance of Italian wine cooperatives?

Andrea Mattia Pacifico[1,*], Massimiliano Calvia[2], Giulio Malorgio[1]

[1] *Department of Agricultural and Food Sciences, University of Bologna, Italy*
[2] *Faculty of Agricultural, Environmental and Food Sciences, Free University of Bozen-Bolzano, Italy*
*Corresponding author. E-mail: andreamattia.pacifico@unibo.it

OPEN ACCESS

Citation: Pacifico, A. M., Calvia, M., & Malorgio, G. (2025). What is driving the performance of Italian wine cooperatives? *Italian Review of Agricultural Economics* 80(3): 117-130. DOI: 10.36253/rea-16585

Received: July 11, 2025

Revised: November 28, 2025

Accepted: December 4, 2025

Data Availability Statement: Data will be made available by the corresponding author upon request.

Competing Interests: The Author(s) declare(s) no conflict of interest.

Guest Editor: Anna Irene De Luca

ORCID
AMP: 0000-0002-3507-7580
MC: 0000-0002-1478-5211
GM: 0000-0001-6899-8880

Abstract. Cooperatives have long been central to the European wine sector, yet comprehensive national-level analyses of their performance determinants remain scarce. This study investigates the financial and economic drivers of Italian wine cooperative performance using a fixed-effects panel framework on an unbalanced sample of 452 entities over the 2021-2023 period. The analysis tests the effects of cooperative size (total assets, turnover), internal financing capacity (cash flow), capital structure (financial autonomy, debt-to-equity ratio), and liquidity ratios (current, quick) on both earnings before interest, taxes, depreciation, and amortisation (EBITDA) and return on sales (ROS). The findings indicate that the cooperative size significantly influences performance. Estimates for cash flow and financial autonomy indicate that the internal financing capacity is a key driver of cooperative performance. The results underscore the relevance of governance and managerial structures in optimising resource allocation and liquidity management to harness cooperative principles without compromising competitiveness. Overall, this study provides actionable insights for policymakers and cooperative boards aiming to foster sustainable growth in the evolving wine market.

Keywords: wine cooperatives, economic performance, profitability, wine economics, fixed-effects.
JEL codes: C23, L25, Q13.

HIGHLIGHTS

- A fixed-effects model is applied to panel data from 452 Italian wine cooperatives to identify performance drivers.
- Cooperative size, cash flow, and financial autonomy significantly influence profitability.
- A structural trade-off emerges between mutualistic practices and short-term liquidity performance.
- Governance and management are key to balancing mutualistic principles with market-driven strategies.

1. INTRODUCTION

The wine industry is increasingly influenced by globalisation, evolving consumption patterns, and shifts in lifestyles, leading to changes in the market environment. These shifts are driven by the ever-greater diversification of consumer preferences (Alpeza *et al*., 2024; Caracciolo *et al*., 2015), increased internationalisation (Behmiri *et al*., 2019; Festa *et al*., 2020), and rising demands for innovation and new sustainability standards (Fragoso, Vieira, 2024). Consequently, companies have been required to adopt more professionalised strategies through structural and organisational changes to remain competitive and support higher activity levels (Mozas-Moral *et al*., 2021).

Within this context, cooperatives have emerged as a distinct organisational means that links small and medium-sized wine and grape producers through strategic alliances and mutual commitment, enabling collective responses to market challenges (Frick, 2017). Key cooperative principles, including voluntary and open membership along with democratic member control, define them as people-centred organisations that prioritise social equity, local community development, and access to education and information (Marques, Teixeira, 2023).

In the wine industry, cooperatives have demonstrated the sustainable development of the sector (D'Amato *et al*., 2021; Pliakoura *et al*., 2021). They successfully integrate economic and social sustainability by encouraging sustainable farming practices (Troiano *et al*., 2023), while contributing to lowering transaction costs and improving economies of scale (Coelho, 2024). Specifically, cooperatives support grape and wine producers in managing downstream supply chain phases, protecting them from the bargaining power of buyers. Consequently, cooperatives provide protection against adverse market fluctuations and enhance sector cohesion (Pomarici *et al*., 2021). The coronavirus disease 2019 (COVID-19) pandemic underscored this adaptive capacity, with wine cooperatives strategically prioritising digitalisation efforts in communication, e-commerce, online sales, and advertising (Borsellino *et al*., 2024). Moreover, cooperatives have demonstrated competitiveness with private wineries regarding product quality and reputation (Schamel, 2014).

Cooperatives have a long-standing tradition in European wine-producing countries, such as France, Italy, Spain, and Portugal, accounting for more than half of total wine production by volume (Richter, Hanf, 2021). In Italy, wine cooperatives ensure economic sustainability for small farms by leveraging the entrepreneurial skills and experience of producers, fostering a sustainable and collaborative business model (Pomarici *et al*., 2021). The Italian wine sector includes 459 cooperatives with 136,498 members, generating €6.4 billion in turnover and employing 10,633 people (Licciardo, Fontanari, 2024). A mutual purpose prevails in the Italian wine cooperatives, with members contributing over half of total product acquisitions in terms of volume or value (Borsellino *et al*., 2020). Wine cooperatives generally operate under two organisational models. First-tier cooperatives, which bring together grape producers to process and market wine collectively, and second-tier cooperatives, which coordinate multiple simple cooperatives and may also manage wine estates, combining member-based production with vertically integrated activities. Although cooperatives account for over 55% of Italy's total wine production, approximately 25% of their output is bottled and marketed directly, while the remaining share is commercialised through investor-owned firms specialised in marketing and distribution (ISMEA, 2024; Malorgio *et al*., 2013; Pomarici *et al*., 2021).

Overall, the underlying governance structure of cooperatives – typically characterised by a strong producer orientation rooted in mutuality principles and heterogeneous membership – may constrain the adoption of market-driven strategies. As a result, wine cooperatives are challenged to establish a competitive industry position by shifting to managerial principles and performance-driven strategies to adapt to globalisation, maturing markets, and climate change (Ferrer *et al*., 2019; Schamel, 2018).

A knowledge gap remains due to the lack of comprehensive, national-level analyses that have systematically investigated the drivers of wine cooperative performance, a limitation largely attributable to the methodological complexity of this task. In cooperative accounting systems, profits are embedded within operating costs, and the allocation of member remuneration as operating cost biases conventional profitability ratios, underscoring that performance cannot be interpreted according to the same criteria used for investor-owned firms. This study develops a national-level analysis of financial and economic indicators of Italian wine cooperatives to identify the key performance determinants. There are two objectives: to examine cooperative behaviour within the evolving wine market context; and to provide actionable insights and recommendations for cooperative managers and policymakers to support economic sustainability and enhance organisational resilience.

2. BACKGROUND

The main distinction between cooperative and investor-owned firms lies in ownership rights and objective functions. While investor-owned firms aim to maximise total profit, cooperatives are designed to maximise the value per unit of input pooled by their members. This objective is typically achieved through the maximisation of member returns, the distribution of patronage refunds, and the minimisation of costs (Royer, 2014). In cooperatives, decision-making is decentralised, control rights are shared, and there is no single residual claimant (Ben-Ner, 1987). A distinctive feature of cooperative enterprises is their institutional structure, in which members act as entrepreneurs, performing governance and strategic decision-making. Accordingly, members assume the business risk, as their remuneration varies with the cooperative's economic performance (Tessitore, 1990).

The neoclassical theory has traditionally regarded cooperatives as inefficient due to vaguely defined property rights and agency problems that limit the efficient allocation of productive resources (Frick, 2017). The interpretation of the economic role of cooperatives has been developed through advances in firm theory mainly driven by Coase's (1937) neo-institutionalist perspective on property rights. Alchian, Demsetz (1972) argued that organisational forms rooted in cooperation replace market mechanisms whenever it is not possible to distinguish individual efforts from the overall joint effort contributing to the realisation of a specific output. This leads to the problem of free-riding, which refers to situations where individuals may reduce their personal effort while benefiting from the efforts of the others. Free-riding problems have a greater impact on cooperative enterprises, where members are simultaneously owners and contributors, and property rights are not specified and, thus, cannot be traded (Green, Laffont, 1977). Unlike investor-owned firms, where both the volume and quality of output are contractually defined, cooperative members may allocate part of their production to alternative markets whenever external prices are more favourable than the internal price set by the cooperative.

The mechanisms for internal governance and incentive alignment help mitigate these challenges. In particular, while the members' direct participation in management mitigates free-riding problems in small and medium-sized cooperatives, difficulties persist in measuring each member's actual contribution and risks of free-riding in large cooperatives. Integrating elements of agency, property rights, and financial theories, Jensen, Meckling, (1976) shifted the focus on the separation of ownership and control. They analysed the relationship between a principal (e.g., the firm's owner), whose objective is to maximise a specific function, and an agent (e.g., the manager), who is supposed to act in the principal's interest. Agency problems emerge when there are information asymmetries and conflicting interests between the agent and the principal; they represent a significant governance challenge that might lead to increased monitoring costs (Jensen, Meckling, 1976). Although efficiency losses can potentially be minimised, they cannot be fully resolved (Prendergast, 1999). Under such conditions, market coordination becomes inefficient, and organisational control is required. Nonetheless, several governance mechanisms have been proposed to mitigate these inefficiencies. As Frick (2017) argued, managing entry and exit barriers to reduce adverse selection and moral hazard, combined with effective monitoring systems, can help to align the interests of heterogeneous members. Moreover, vertical integration through cooperatives enables farmers to internalise externalities, to access collective goods, and to reduce transaction costs associated with organising exchanges and mitigating opportunistic behaviour (Royer, 1999; Staatz, 1987). Notably, the effectiveness of cooperatives is closely linked to the extent to which members act in accordance with cooperative principles, including their propensity to invest equity capital, their active participation in governance, and the quality and quantity of the raw materials they supply (Fanasch, Frick, 2018).

Despite these theoretical issues, cooperatives have been shown to provide tangible benefits, especially for the agricultural sector. Cooperatives enable addressing the holdup problem and opportunistic behaviour related to asset specificity by strengthening farmers' market power and securing access to markets, particularly in fragmented or specialised market settings (Staatz, 1987). This is particularly relevant in the wine industry, where downstream firms (i.e., wineries purchasing grapes) may exert market power, leading to opportunistic behaviour (Albanese *et al.*, 2015). The high level of risk in agriculture further exacerbates such issues, making cooperatives an effective tool for risk management (Koç, Cennet, 2024).

The predominant model characterising the agricultural domain – and, in particular, the wine sector – is the producer cooperative, which is owned and governed by producers who contribute production inputs, including capital assets, intermediate goods, and labour (Fanasch, Frick, 2018; Hansmann, 1999). Farmers combine their inputs and may jointly own equipment like harvesters or grape presses (Agbo *et al.*, 2015). Members deliver their produce (e.g., grapes in the case of wine cooperatives) through a transaction at an internal transfer price, which is set according to the cooperative's annual economic result. This price is generally lower than the prevailing market price at the time of delivery, as the retained margin is used to generate a surplus that is subsequently redistributed to members.

Previous studies have examined different aspects of wine cooperative performance. Couderc, Marchini (2011) analysed the performance of 25 French and Italian wine cooperatives, measured as total sales per product unit, using both survey and financial data, with the aim of examining the relationship between governance structures and commercial strategies. Based on survey data, Ferrer *et al.* (2019) found that Spanish cooperatives neither underperform nor lack innovation capabilities compared with investor-owned firms, although their performance drivers differ due to distinct organisational objectives. Challita *et al.* (2019) investigated the relationship between branding and financial performance in 207 French firms, including wine cooperatives and investor-owned firms. Using both survey and financial data, they concluded that the cooperative ownership model was the primary determinant of financial performance stability, as measured by return on assets (ROA) and return on sales (ROS). Borsellino *et al.* (2020) demonstrated that, within Sicilian wine cooperatives, adopting hybrid organisational models and engaging in strategic alliances, such as vertical quasi-integration, can enhance market competitiveness, financial stability, and packaged wine sales. Finally, despite theoretical concerns about cooperative inefficiencies, D'Amato *et al.* (2021) showed that Italian wine cooperatives were as economically efficient as investor-owned firms, often outperforming them between 2009 and 2018 based on an adjusted earnings before interest, taxes, depreciation, and amortisation (EBITDA) measure.

3. MATERIALS AND METHODS

3.1. Data

The "*Analisi Informatizzata delle Aziende Italiane*" (AIDA) database (Bureau Van Dijk, 2025) was used to extract the main financial and economic indicators for Italian cooperatives involved in grape cultivation or wine production (Table 1). The analysis encompasses the years 2021, 2022, and 2023 to provide a recent post-COVID-19 pandemic overview of the wine cooperative sector in Italy. Wine cooperatives were selected via a two-channel strategy using the NACE Rev. 2 classification (Statistical Classification of Economic Activities in the European Community). The first search explicitly addressed grapes and wine producers by looking for the codes "0121 Growing of grapes" and "1102 Manufacture of wine from grape" and resulted in an initial sub-sample of 596 active wine cooperatives. The second search implicitly targeted the wine industry by first selecting the more heterogeneous code "016 Support activities to agriculture and post-harvest crop activities". Only those cooperatives that operated in the wine sector were selected by explicitly searching for the words "wine" and "cellar" in the name of the company and/or in the product services they claim to provide. This step yielded a second sub-sample of 36 active wine cooperatives. The two datasets were then merged, and duplicates were removed.

The sample revealed substantial heterogeneity, with first-tier cooperatives focused mainly on grape production and second-tier cooperatives displaying higher lev-

Table 1. Variables used to analyse the performance of Italian wine cooperatives.

Variable	Definition	Unit of measure
EBITDA	Earnings before interest, taxes, depreciation, and amortisation	Thousands of euros (000 €)
Return on sales (ROS)	EBIT/turnover	Percentage (%)
Return on investments (ROI)	EBIT/(financial debts + equity)	Percentage (%)
Assets	Total assets	Thousands of euros (000 €)
Turnover	Total sales	Thousands of euros (000 €)
Cash flow	Operating cash flow	Thousands of euros (000 €)
Employees	Number of employees	Number
Current ratio	Current assets/current debts	Ratio
Quick ratio	(Current assets – inventories)/current debts	Ratio
Autonomy	Total equity/total assets	Percentage (%)
Financial sustainability	Financial charges/total debts	Percentage (%)
ST debts	Current debts/total debts	Percentage (%)
Debt-to-equity ratio	Total debts/total equity	Ratio
Labour productivity	Added value/employees	Thousands of euros (000 €)
Labour-added value share	Personnel costs/added value	Percentage (%)
Age	Age of wine cooperatives	Number of years
Production value	Value of total production	Thousands of euros (000 €)

els of vertical integration. However, this distinction is not always clearly captured by NACE codes, as many cooperatives operate across multiple stages, generating overlaps that blur classification boundaries. Those wine cooperatives with turnover, product value, and number of employees equal to zero were also deleted from the sample to remove very unlikely and/or unreliable features. This procedure resulted in an unbalanced panel of 452 wine cooperatives ready for further statistical analyses; this represents about 99% of the total Italian wine cooperatives.

The interpretation of economic performance in cooperatives requires specific methodological caution, as traditional income statement analysis may not fully capture the effects of their mutualistic structure. In cooperative firms, standard profit and loss statements embed member remuneration within operating costs, including settlement prices, services provided to members, and the remuneration of member-financed loans. As a result, the reported margins do not reflect residual profitability, but rather the outcome of mutualistic policies aimed at maximising member benefit. Because the variables available in the database do not allow these elements to be disentangled, and given the large size of the sample and the heterogeneity of production values across different areas, the empirical analysis relied exclusively on observed financial statements, without introducing any assumptions regarding board decisions on settlement prices. Therefore, profitability indicators were interpreted as measures of operating performance after member remuneration and used exclusively to compare cooperatives of different sizes operating under the same institutional and accounting constraints.

3.2. Regression analysis

The analysis was based on a panel data framework to fully exploit the cross-sectional and temporal characteristics of the dataset. More specifically, a classical fixed-effects model was considered. Following the compact notation of Verbeek (2004), it is written as Equation (1):

$$y_{it} = \alpha_i + x_{it}^{'}\beta + \varepsilon_{it} \qquad (1)$$

where y_{it} and x'_{it} are, respectively, the dependent variable and the (transposed) vector of independent variables referring to the i-th wine cooperative (i = 1,..., 452) and t-th years (t = 2021,..., 2023); β measures the partial effects of the independent variable and is constant with respect to i and t; and the intercept α_i captures all the effects relative to the i-th wine cooperative, which are constant over time. The "within estimator", available in Stata 17, was used to estimate the model. Within this estimation framework, the intercept α_i is the average of the individual effects of the wine cooperatives, while all βs are consistently estimated.

There is theoretical as well as empirical justification for the appropriateness of the fixed-effects model. First, unlike the pooled framework, the fixed-effects model explicitly considers the heterogeneity of the individual wine cooperatives. For this reason, it is possible to assume that the pooled model is nested within the fixed-effects model, that is to say, the former is a restricted version of the latter. This justifies the use of an F-test to test whether the fixed-effects model is indeed a more complete and, therefore, appropriate framework for analysing the problem at hand (Gujarati, 2014). Second, the absence in this analysis of time-constant determinants of the performance of wine cooperatives together with the unbalancedness of the panel considered suggest that a fixed-effects model is preferable to a random-effects model (Wooldridge, 2016). This theoretical expectation is empirically corroborated by the Hausman test, which represents the gold standard to assess substantial differences between fixed effect models and random effect models addressing a certain research question. Last but not least, the presence of time fixed effects is tested using a classical F-test on the dummy year variables included in the model.

Two dependent variables – EBITDA (log-transformed) and ROS – were chosen to identify the determinants of the performance of Italian wine cooperatives. EBITDA provides a comprehensive description of a firm's operating profitability, which considers value losses from tangible and intangible assets, while ROS captures the operating margin per unit of sales. ROI was excluded from the regression analysis because many values were missing across the wine cooperatives in the sample, particularly among smaller ones. Therefore, it was retained solely for descriptive purposes.

4. RESULTS AND DISCUSSION

4.1. Descriptive statistics

Table 2 provides a summary of the descriptive statistics of the full sample for a comprehensive overview of the key financial and economic indicators of Italian wine cooperatives during the 2021-2023 period.

The Italian wine cooperatives have an average age of approximately 49 years since foundation, indicating a well-established sector characterised by substantial organisational maturity. On average, cooperatives employ 24 workers, each generating € 51,780 in gross value added. 71% of total value added is allocated to labour, under-

Table 2. Summary statistics of wine cooperatives (full sample).

Variable	Obs.	Mean	Std. dev.	Min	Max	Median	A
EBITDA	1291	510.66	1280.34	-2940.20	20635.39	137.43	79
ROI	959	2.27	5.43	-27.87	29.09	1.56	52
ROS	1243	1.35	7.67	-49.43	29.72	1.31	97
Assets	1291	14900.47	38075.38	9.61	466743.70	3982.73	0
Turnover	1291	10456.87	28499.92	3.63	311511.40	2158.39	0
Cash flow	1291	470.91	1292.15	-4015.59	20098.75	104.88	80
Employees	1201	24.44	84.01	1	1601	10	0
Current ratio	1288	1.88	3.55	0.01	80.67	1.31	0
Quick ratio	1288	1.11	2.17	0.00	40.01	0.73	0
Autonomy	1291	25.32	21.45	-113.50	95.34	23.24	29
Financial sustainability	1291	1.08	1.05	0	10.25	0.80	0
ST debts	1291	73.00	23.95	0.00	100.00	76.39	0
Debt-to-equity ratio	1291	16.73	197.54	-726.22	6703.46	2.72	29
Labour productivity	1201	51.78	108.81	-2364.37	473.35	49.16	21
Labour-added value share	1291	71.44	218.84	-2482.62	5108.33	63.96	26
Age	1291	48.82	28.43	1	131	55	0
Production value	1291	11328.56	30430.33	3.63	323255.60	2413.48	0

Note: The variables and their units are described in Table 1. The "A" column indicates the number of wine cooperatives with at least one negative value for a certain variable. Abbreviations: Obs., number of observations; Std. dev., standard deviation; Min, minimum; Max, maximum.

scoring a strong commitment to workforce remuneration. This is consistent with cooperative principles, as profits are not reported as a separate item and the portion of value added directed to members is embedded in the payments distributed to them.

Appropriate profitability evaluation pertaining to cooperatives should consider the diversity of the owner structure and the companies' objectives of maximising member results. This is particularly relevant when analysing ROI and ROS. Profitability indicators suggest adequate returns, while the autonomy ratio points to a moderate level of financial independence, with equity financing approximately one-quarter of total assets.

The average cash flow indicates a solid self-financing capacity across the sample in the period under analysis, although the high standard deviation reveals substantial heterogeneity, with 80 cooperatives reporting negative cash flow. The quick ratio points to limited short-term liquidity when inventories are excluded, consistent with a business model where a significant share of current assets is tied up in wine inventories. In contrast, the current ratio suggests a conservative approach to liquidity and a general ability to meet immediate obligations, a finding reinforced by the low standard deviation, indicating consistent liquidity management practices across the sample.

The average debt-to-equity ratio, characterised by high variability across the sample, reflects diverse capital structures and varying degrees of leverage risk. Wine cooperatives are quite reliant on debt financing, with 73% of total debt being short term. This result highlights a substantial divergence from Italian investor-owned wine companies, which operate with an average debt ratio of less than 40% (Mediobanca, 2022). This reliance is further explained by the financial sustainability indicator (1%), which underscores both the low cost of debt and its widespread use within cooperatives. When the ROI exceeds the financial sustainability ratio (i.e., the cost of total debts), the cooperative operates under a favourable financial condition, with potential for value creation through efficient capital allocation (Magni, 2021). Caution is warranted, however, as total debts comprise both onerous and non-onerous liabilities, with the latter accounting for 73% of the total. In such contexts, debt financing can enhance returns to members when operations are profitable (Pokharel *et al.*, 2019). For investor-owned wine firms, the average ROI is approximately 5% (Mediobanca, 2022), a value that is markedly higher than that recorded for the cooperatives in the sample, which present a satisfactory average of around 2.3%. This difference does not imply lower efficiency of cooperatives; instead, it should be interpreted as a consequence of the mutualistic principles adopted in determining raw material procurement costs. Such treatment does not prevent cooperatives from pursuing the maximisation of operating results.

The average production value is €11.3 million, with a standard deviation of €30.4 million, indicating a highly

Table 3. Summary statistics of small Italian wine cooperatives (turnover ≤ the median of €2.158 million) in the sample.

Variable	Obs.	Mean	Std. dev.	Min	Max	Median	A
EBITDA	646	44.80	87.59	-815.77	485.99	29.30	72
ROI	359	3.04	7.60	-27.87	29.09	2.26	36
ROS	602	1.19	10.50	-49.43	29.72	1.89	78
Assets	646	1408.98	1736.98	9.61	17601.62	914.32	0
Turnover	646	638.94	665.86	3.63	3870.09	383.77	0
Cash flow	646	29.53	135.95	-2851.16	485.54	20.72	76
Employees	564	6.67	12.68	1	267	5	0
Current ratio	643	2.29	4.94	0.01	80.67	1.37	0
Quick ratio	643	1.41	2.99	0	40.01	0.78	0
Autonomy	646	21.48	25.14	-113.50	95.34	19.35	29
Financial sustainability	646	1.15	1.27	0.00	10.25	0.77	0
ST debts	646	70.46	28.74	0	100	76.57	0
Debt-to-equity ratio	646	23.19	269.78	-726.22	6703.46	3.00	29
Labour productivity	564	32060.50	37.90	-233.18	360.95	24.90	19
Labour-added value share	646	83.93	308.44	-2482.62	5108.33	73.12	24
Age	646	35.15	27.19	1	118	26	0
Production value	646	714.78	691.64	3.63	2413.48	446.76	0

Note: The variables and their units are described in Table 1. The "A" column indicates the number of wine cooperatives with at least one negative value for a certain variable. Abbreviations: Obs., number of observations; Std. dev., standard deviation; Min, minimum; Max, maximum.

heterogeneous size structure that includes both small and large cooperatives. This variability is further confirmed by the average assets (€14.9 million) and turnover (€10.5 million), with corresponding medians of €3.98 million and €2.16 million, respectively. Moreover, the average asset-to-turnover ratio of approximately 1.4 further indicates the capital requirements of wine production.

Given this heterogeneity, the sample was divided into two groups based on whether turnover was above or below the median, classifying cooperatives as small (Table 3) and large (Table 4), respectively.

It is worth noting that the average turnover of cooperatives during the 2021-2023 period appears to have been affected by the effects of the post-COVID-19 period. Large cooperatives are older, suggesting more established governance structures, with on average 40 and 7 employees, respectively.

The higher average ROI among smaller cooperatives (3.04%) can be explained by their leaner asset base and greater operational flexibility. With mean total assets of €1.4 million, compared with €28.4 million for larger cooperatives, even modest earnings translate into a relatively high ROI. However, the higher ROI for small cooperatives reflects the small scale of operations rather than superior profitability or efficiency.

ROS is affected by operating income and the value of goods sold. Based on the values, there is a lower sales profit for smaller cooperatives than larger ones, indicating that the latter produce higher-value products or benefit from economies of scale, achieving higher margins per unit sold (Gezahegn *et al.*, 2019; Ortmann, King, 2007). The low EBITDA observed among small cooperatives further illustrates these structural constraints. Operating at a smaller scale limits their ability to benefit from economies of scale, while their focus on member value often translates into reduced margins.

With reference to the composition of liabilities, small cooperatives also exhibit higher debt ratios, with 29 of them reporting negative equity and an average cash flow of €29,530. These results reflect a mutualistic model that prioritises the redistribution of earnings to members over reinvestment, as shown by Rebelo, Caldas (2015), who highlighted that agricultural cooperatives with a more mutualistic orientation tend to distribute earnings rather than accumulate equity. The low absolute value of cash flow, despite a relatively high ROI, is another consequence of the small asset base and modest operating scale. In comparison, larger cooperatives, with relatively lower leverage and substantially higher cash flows, are less financially stressed and better positioned to retain and reinvest resources (Pokharel *et al.*, 2019). This enhances their competitiveness and resilience by enabling strategic investments, improving their capacity to respond to market fluctuations, and supporting innovation. Notably, the weight of short-term debt is consistently high across cooperatives, largely due to the amounts owed to members for grape contributions, typically recorded under current liabilities. This debt, often

Table 4. Summary statistics of large Italian wine cooperatives (turnover > the median of €2.158 million) in the sample.

Variable	Obs.	Mean	Std. dev.	Min	Max	Median	A
EBITDA	645	977.24	1685.29	-2940.20	20635.39	470.26	8
ROI	600	1.81	3.48	-22.91	23.82	1.37	17
ROS	641	1.49	3.27	-44.14	23.11	1.10	19
Assets	645	28412.88	50353.71	1235.71	466743.70	13273.67	0
Turnover	645	20290.02	37855.47	604.51	311511.40	8743.31	0
Cash flow	645	912.99	1713.13	-4015.59	20098.75	395.39	5
Employees	637	40.17	112.46	1	1601	18	0
Current ratio	645	1.47	0.80	0.48	10.01	1.28	0
Quick ratio	645	0.83	0.56	0.08	5.40	0.70	0
Autonomy	645	29.17	16.08	0.076	94.17	26.68	0
Financial sustainability	645	1.01	.77	0	3.84	0.81	0
ST debts	645	75.54	17.58	7.76	100.00	76.39	0
Debt-to-equity ratio	645	10.26	72.00	0.05	1300.39	2.55	0
Labour productivity	637	69238.48	142.88	-2364.37	473.35	74.65	3
Labour-added value share	645	58.94	18.27	-97.14	271.72	60.05	3
Age	645	62.51	22.43	3	131	63	0
Production value	645	21958.79	40351.30	2461.57	323255.60	9667.53	0

Note: The variables and their units are described in Table 1. The "A" column indicates the number of wine cooperatives with at least one negative value for a certain variable. Abbreviations: Obs., number of observations; Std. dev., standard deviation; Min, minimum; Max, maximum.

linked to the cooperative nature of operations rather than traditional bank loans, structurally increases overall indebtedness, thereby progressively reducing the financial autonomy of cooperatives, especially among smaller entities.

4.2. Panel regression analysis results

The model in Equation 1 was estimated twice using two different dependent variables, namely log(EBITDA) for Model 1 and ROS for Model 2. For the sake of comparability, both the models employ the same set of independent variables, specifically log(assets), log(turnover), log(cash flow), log(employees), the current ratio, the quick ratio, autonomy, financial sustainability, ST debts, the debt-to-equity ratio, labour productivity, and labour-added value share. The use of log-log relationships such as those in Model 1 helps convey economic information in the form of elasticities, thereby linking percentage changes in the independent variables to the corresponding percentage changes in the dependent variable (Hill *et al.*, 2018). Year dummies are also added among the independent variables to control for time fixed effects. More specifically, the year 2021 is used as the base year and is omitted to avoid a dummy variable trap. This setting provides a comprehensive yet consistent framework of determinants of the performances of the wine cooperatives. The results of the panel regression analysis are outlined in Table 5.

Despite the slightly different information conveyed by the dependent variables EBITDA and ROS, the model results reveal the determinants that help outline the main drivers underlying the performance of wine cooperatives. Model 1 is characterised by a relatively high R^2 (within) of 0.8541, so it explains a high percentage of the variance.

The size of the cooperatives, measured by total assets and turnover, emerges as a key determinant of performance in both the models, with a positive and significant effect ($P < 0.01$) on EBITDA and ROS. These variables, which capture the organisational scale of cooperatives, play a strategic role in processes such as mergers and acquisitions (Arcas *et al.*, 2011; Liang *et al.*, 2023). Indeed, larger cooperatives can more easily access larger markets and financial resources, thereby enhancing economies of scale and operational efficiency (Sala-Ríos, 2024). However, expanding firm size, which is a common strategic objective across business models, requires additional effort for cooperatives. Specifically, cooperatives must find a balance between configuring the business as a projection of their members' activities and achieving autonomous economies capable of competing in the market and generating self-financing flows to sustain growth.

Dimensional expansion may occur either through internal growth, enabled by the capabilities and resources available within the organisation, or through external growth via the acquisition or merger of existing coopera-

Table 5. Fixed-effects estimation results.

	Model 1	Model 2
Dependent variable	log(EBITDA)	ROS
Independent variables		
log(Assets)	0.2523246*** (0.0602453)	3.158571*** (0.9313465)
log(Turnover)	0.2519245*** (0.0341156)	2.297392*** (0.5348394)
log(Cash flow)	0.4290764*** (0.0161348)	1.16292*** (0.2377854)
log(Employees)	0.0220244 (0.0256627)	0.2986411 (0.3972093)
Current ratio	0.0300256** (0.0130235)	0.0464374 (0.2057876)
Quick ratio	-0.0588755** (0.0237573)	-0.1001972 (0.3767668)
Autonomy	0.0047038** (0.0019465)	0.1127394*** (0.0303431)
ST debts	-0.0013445 (0.0008499)	0.0140284 (0.0131282)
Debt-to-equity ratio	-0.0002373 (0.0002331)	0.0008687 (0.0035992)
Labour productivity	-0.0002304 (0.0003073)	-0.0036405 (0.0047464)
Labour-added value share	-0.0192555*** (0.0011246)	-0.13334*** (0.0153323)
Year 2022	-0.0060094 (0.0128251)	-0.5900901*** (0.1987951)
Year 2023	0.0446733*** (0.0137565)	-0.2917924 (0.2127952)
Intercept	0.080926 (0.5624411)	-43.66395*** (8.628822)
Number of observations	1083	1075
Number of wine cooperatives	421	417
R^2 (within)	0.8541	0.3798

Note: The variables are described in Table 1. * $P < 0.1$, ** $P < 0.05$, and *** $P < 0.01$.

tive entities. The latter represents the primary and most recurrent strategy of external growth, as it is both cost-effective and institutionally rational, although its implementation is often constrained by local interests and cultural resistance.

Cash flow, representing the main internal source of financing, is also recognised as a key driver of cooperative performance. Its impact is positive and significant (P < 0.01) for both EBITDA and ROS. In particular, a 1% increase in the cash flow generates a rough 0.43% increase in EBITDA. Positive cash flow enables cooperatives to extend trade credit, which operates as a strategic investment tool, particularly for smaller cooperatives. By strengthening commercial relationships and supporting sales growth, this mechanism contributes to improved operating performance (Martínez-Victoria, Maté-Sanchez-Val, 2021).

Two solvency indicators are considered in this analysis, namely the debt-to-equity-ratio and financial autonomy, whose impact on performance should be interpreted considering the descriptive results provided in Tables 2-4. Two peculiar yet relevant factors emerge. First, the non-significance of the debt-to-equity ratio highlights that although the Italian wine cooperatives have a relatively high level of indebtedness, it does not impact their economic performance. Second, the effect of autonomy on performance is positive and significant with respect to both EBITDA (P < 0.05) and ROS (P < 0.01). A stronger reliance on member equity reflects a governance orientation towards internal resource mobilisation and long-term mutualistic stability, thereby enhancing economic performance. According to Sala-Ríos (2024), this behaviour stems from the tendency of agricultural cooperatives to be highly indebted and, as such, less able to raise funds from banks. Consequently, their economic performance becomes highly dependent on internal rather than external funds.

Liquidity reflects a firm's ability to minimise risk and financing costs by meeting short-term liabilities (Neves *et al.*, 2022). While maintaining adequate liquidity is essential for supporting profitability, both excess and shortage entail significant risks. Excessive liquidity may result in idle resources and missed investment opportunities, whereas insufficient liquidity can compromise solvency and limit production capacity (Ehiedu, 2014; Sala-Ríos, 2024). Liquidity indicators, namely the current ratio and the quick ratio, appear to have a significant effect on performance only for EBITDA. Specifically, the positive and significant (P < 0.05) effect of the current ratio on EBITDA in wine cooperatives reflects the fact that a balanced liquidity structure, including inventory, is a determinant of economic performance. Despite its significance (P < 0.05), the quick ratio has a negative effect on EBITDA, thus underscoring two relevant aspects: first, inventories play a fundamental role in sustaining overall liquidity for wine cooperatives. Second, performance improvements tend to reduce internal liquidity due to short-term obligations and immediate value redistribution to members. These findings are consistent with a previous study that emphasised the role of inventory liquidity to explain profitability in agricultural cooperatives (Yen *et al.*, 2025). Moreover, the results highlight the distinctive financial structure of cooperatives, characterised by lower capitalisation levels, higher indebtedness, non-distributable mandatory social funds, and a variable share capital (Sala-Ríos, 2024). Cooperatives prioritise mutualistic transfers, typically through higher payment for delivered products or member refunds, thus generating a structural trade-off between redistribution of operating return and short- and long-term financial solvency.

The non-significance of the current ratio and the quick ratio on ROS, in contrast, can be ascribed to the relatively limited role liquidity plays in explaining operating margins. In fact, ROS is influenced more by pricing strategies, cost control, and value-added processes than by short-term liquidity dynamics. A final analysis of the labour variable highlights three fundamental aspects. First, the variable employees is not a significant determinant of performance. Similar considerations also hold for labour productivity, whose effect is also not statistically significant. This result reflects the positive role of technological investments, as evidenced by the significance of assets, which contribute to production processes by replacing labour input. Conversely, as expected, the labour-added value share has a negative and significant effect on both EBITDA and ROS ($P < 0.01$). Specifically, a 1% increase in the labour-added value share is associated with a 1.93% decrease in EBITDA, and a 1.33% reduction in ROS.

The results of some additional tests are provided to empirically validate the choice of the econometric setting employed throughout this study. The results of the F-tests regarding the null hypothesis of no presence of time fixed effects for both Model 1 and Model 2 are reported in Table 6. The hypothesis is rejected in both cases, thus emphasising the importance of including dummy year variables to control for time fixed effects.

F-tests are again used to test the null hypothesis that there are no individual fixed effects for both Model 1 and Model 2. This hypothesis is rejected for both models, which suggests that the fixed-effects model is superior to the pooled one, thus substantiating the use of the former.

Finally, Table 8 shows the results of the Hausman test to empirically test whether a fixed-effects or a random-effects framework is appropriate. The estimates of the fixed-effects and random-effects models seem to substantially differ from each other for both Model 1 and Model 2, thus suggesting that the former might be more appropriate than the latter for the problem at hand.

Table 6. Testing the presence of time fixed-effects.

H_0: No presence of time fixed effects		
	Model 1	Model 2
F-test	$F(2, 649) = 8.31^{***}$	$F(2, 645) = 4.42^{**}$

Note: ** $P < 0.05$ and *** $P < 0.01$.
Source: authors' calculations.

Table 7. Testing the presence of fixed-effects.

H_0: No presence of individual fixed effects		
	Model 1	Model 2
F-test	$F(420, 649) = 5.90^{***}$	$F(416, 645) = 5.23^{***}$

Note: *** $P < 0.01$.
Source: authors' calculations.

Table 8. The Hausman test.

H_0: No difference in the estimates of the fixed and random effects.		
	Model 1	Model 2
χ^2 test	$\chi^2(13) = 113.13^{***}$	$\chi^2(13) = 113.00^{***}$

Note: *** $P < 0.01$.
Source: authors' calculations.

5. CONCLUSIONS

Cooperatives have historically played a central role in shaping traditional European wine markets, with the Italian case standing out as particularly significant. Their organisational model is characterised by the coexistence of mutualistic objectives and heterogeneity in terms of size, vertical integration, governance structure, and market strategy, making them a distinctive form within conventional corporate governance frameworks. Cooperation constitutes a key channel for enhancing the value of Italian wine production, accounting for over half of the national output. Notably, almost all the raw materials processed by wine cooperatives are supplied by their members. This confirms the mutualistic nature of Italian wine cooperatives and reflects their strong embeddedness in the local territory. As a result, cooperatives exercise effective supply chain control over production and embody a natural mission to protect and promote the origin of their products.

The present study addresses a gap in the existing literature by identifying and examining the determinants of performance in Italian wine cooperatives during the 2021-2023 period. The comparison between smaller and larger cooperatives reveals that cooperative size is associated with stronger operating performance, with larger cooperatives showing higher values in key efficiency and profitability indicators. This structural pattern is confirmed by the panel regression analysis results, which indicate that organisational size supports operating performance. There is an exception for ROI, which appears higher in smaller cooperatives. This outcome can be attributed to the organisational simplicity and capital efficiency typical of such entities, characterised by lower investment levels, reduced technological requirements, and greater flexibility in the timing and level of remuneration for delivered products, enabled by the closer relationship between members and governance structures. When excluding capital profitability, the efficiency ratio, expressed as revenue per labour unit, is higher for larger cooperatives. This result suggests that the cooperative model does not entail structural inefficiency when appropriate managerial practices are adopted. In cooperatives, the criterion for determining consumption costs is guided by the objective of serving members, rooted in the principles of mutuality and a non-profit orientation. However, this does not prevent the cooperative under analysis from optimising its behaviour both internally and on the market to enhance operating performance. This suggests that the interests of cooperative management and members are not necessarily divergent – they can, in fact, be aligned.

Larger cooperatives are also better positioned to establish stable relationships with large-scale retailers, to enhance their investment capacity, and to diversify production. These features enhance access to wider distribution channels and contribute to improved market alignment. The consolidation process experienced by Italian wine cooperatives in the last decades, primarily through mergers and acquisitions, has led to a larger production scale and a more effective response to demand trends, including from international markets, where administrative and financial constraints are more pronounced. However, the expansion in size may lead to a weakening of mutualistic aims. There may be a shift from member-focused objectives to market-oriented strategies, with the risk of reducing the role of members from co-owners to simple suppliers.

Moreover, financial and competitive pressures require cooperatives to achieve a certain degree of autonomy from the individual economic structures of members to support internal capital accumulation and to sustain growth. Therefore, there must be balanced management of the economic and financial dimensions. The interdependence between these aspects becomes particularly relevant over the long term, as it allows for the retention of resources needed to finance development activities and to maintain adequate service provision to members. Continued participation in the cooperative is likely to depend on the extent to which members perceive that their expectations are being met. Overall, the results confirm the importance of operational scale, balanced liquidity, and financial autonomy as key determinants of the economic performance of Italian wine cooperatives. This mutualistic structure entails specific managerial features, including the significant role of equity, the frequent reliance on short-term debt owed to members, and a prevailing orientation towards profit redistribution rather than capital accumulation.

Effective governance and management are essential to harness the benefits of size and diversification without compromising cooperative principles. Board composition, transparency, and accountability mechanisms become key factors in aligning strategic choices with member expectations. Therefore, enhancing managerial capacity and governance structures can contribute to a sustainable development path, ensuring that cooperatives remain competitive and resilient in a rapidly evolving industry. In this regard, managerial interventions should focus on improving strategic planning capacities and developing marketing and branding competencies, which are traditionally weaker in producer cooperatives. From a policy perspective, support measures aimed at facilitating cooperative mergers, enhancing access to patient capital, and promoting targeted training in cooperative governance and digital market positioning could significantly improve the ability of wine cooperatives to compete in increasingly global and quality-driven markets.

This study is limited to financial data and does not capture qualitative aspects such as member satisfaction, governance dynamics, or innovation strategies. Nevertheless, the results provide a foundation for further research to examine the micro-fundamentals of cooperatives. Future studies that integrate qualitative methods (e.g., either with interviews or surveys) could improve the knowledge about the economic and organisational processes characterising this business model.

AUTHOR CONTRIBUTIONS

Pacifico A.M.: Conceptualization, Methodology, Data curation, Writing- Original draft preparation, Visualization, Investigation. Writing- Reviewing and Editing.

Calvia M.: Conceptualization, Methodology, Software, Data curation, Writing- Original draft preparation, Investigation, Validation, Writing- Reviewing and Editing.

Malorgio G.: Conceptualization, Methodology, Data curation, Writing- Original draft preparation, Supervision, Validation, Writing- Reviewing and Editing.

REFERENCES

Agbo M., Rousselière D., Salanié J. (2015). Agricultural marketing cooperatives with direct selling: a cooperative–non-cooperative game. *Journal of Economic Behavior & Organization*, 109: 56-71. DOI: https://doi.org/10.1016/j.jebo.2014.11.003.

Albanese M., Navarra C., Tortia E.C. (2015). Employer moral hazard and wage rigidity. The case of worker owned and investor owned firms. *International Review of Law and Economics*, 43: 227-237. DOI: https://doi.org/10.1016/j.irle.2014.08.006.

Alchian A.A., Demsetz H. (1972). Production, information costs, and economic organization. *The American Economic Review*, 62(5): 777-795. http://www.jstor.org/stable/1815199.

Alpeza I., Nižić I., Lukač Z. (2024). The Croatian consumer responses to the European GIs scheme of wine labeling. *New Medit*, 2: 39-51. DOI: https://doi.org/10.30682/nm2402c.

Arcas N., García D., Guzmán I. (2011). Effect of size on performance of Spanish agricultural cooperatives. *Outlook on Agriculture*, 40(3): 201-206. DOI: https://doi.org/10.5367/oa.2011.0051.

Behmiri N.B., Correia L., Gouveia S. (2019). Drivers of wine production in the European Union: a macroeconomic perspective. *New Medit*, 3: 85-96. DOI: https://doi.org/10.30682/nm1903g.

Ben-Ner A. (1987). Producer cooperatives: Why do they exist in capitalist economies? In Powell W.W., Bromley P. (eds) *The Nonprofit Sector: A Research Handbook* (pp. 434-449). Yale University Press, New Haven, USA.

Borsellino V., Galati A., Ilardi C., Theofanous G., Schimmenti E. (2024). Wine industry resilience and strategy under crisis: the case of Sicilian cooperatives. In Galati A., Fiore M., Thrassou A., Vrontis D. (eds) *Agribusiness Innovation and Contextual Evolution* (pp. 249-271). Palgrave Macmillan, Cham. DOI: https://doi.org/10.1007/978-3-031-45738-8_11.

Borsellino V., Varia F., Zinnanti C., Schimmenti E. (2020). The Sicilian cooperative system of wine production: the strategic choices and performance analyses of a case study. *International Journal of Wine Business Research*, 32(3): 391-421. DOI: https://doi.org/10.1108/IJWBR-10-2018-0062.

Bureau Van Dijk (2025). *Analisi informatizzata delle aziende italiane*. https://aida.bvdinfo.com/version202255/home.serv?product=AidaNeo.

Caracciolo F., Vita G.D., Lanfranchi M., D'Amico M. (2015). Determinants of Sicilian wine consumption: evidence from a binary response model. *American Journal of Applied Sciences*, 12(11): 794-801. DOI: https://doi.org/10.3844/ajassp.2015.794.801.

Challita S., Aurier P., Sentis P. (2019). Linking branding strategy to ownership structure, financial performance and stability: case of French wine cooperatives. *International Journal of Entrepreneurship and Small Business*, 36(3): 292-307. DOI: https://doi.org/10.1504/IJESB.2019.097732.

Coase R.H. (1937). The nature of the firm. *Economica New Series*, 4: 386-405.

Coelho A. (2024). The leading wine cooperatives in Argentina and Europe: what are the strategic choices to penetrate the distribution channels in the United States and Canada? *Sustainability*, 16(15): 6376. DOI: https://doi.org/10.3390/su16156376.

Couderc J., Marchini A. (2011). Governance, commercial strategies and performances of wine cooperatives. *International Journal of Wine Business Research*, 23(3): 235-257. DOI: https://doi.org/10.1108/17511061111163069.

D'Amato A., Festa G., Dhir A., Rossi M. (2021). Cooperatives' performance relative to investor-owned firms: a non-distorted approach for the wine sector. *British Food Journal*, 124(13): 35-52. DOI: https://doi.org/10.1108/BFJ-03-2021-0275.

Ehiedu V.C. (2014). The impact of liquidity on profitability of some selected companies: the financial statement analysis (FSA) approach. *Research Journal of Finance and Accounting*, 5(5): 81-90.

Fanasch P., Frick B. (2018). What makes cooperatives successful? Identifying the determinants of their organizational performance. *Journal of Wine Economics*, 13(3): 282-308. DOI: https://doi.org/10.1017/jwe.2018.28.

Ferrer J.-R., Abella-Garcés, S. Maza M.-T. (2019). Spanish wine cooperatives' business performance: innovation capabilities and miles and snow strategies. *Journal of Wine Economics*, 14(4): 409-416. DOI: https://doi.org/10.1017/jwe.2019.36.

Festa G., Rossi M., Kolte A., Situm M. (2020). Territory-based knowledge management in international marketing processes – the case of "Made in Italy" SMEs. *European Business Review*, 32(3): 425-442. DOI: https://doi.org/10.1108/EBR-06-2019-0129.

Fragoso R., Vieira A. (2024). Exploring firm performance of the wine industry in Portugal using a two-stage efficiency analysis. *Studies in Agricultural Economics*, 126(3): 128-139. DOI: https://doi.org/10.7896/j.2838.

Frick B. (2017). Some cooperatives produce great wines, but the majority does not: complementary institutional mechanisms to improve the performance of an indispensable organizational form. *Journal of Wine Economics*, 12(4): 386-394. DOI: https://doi.org/10.1017/jwe.2017.33.

Gezahegn T.W., Van Passel S., Berhanu T., D'Haese M., Maertens M. (2019). Big is efficient: evidence from agricultural cooperatives in Ethiopia. *Agricultural Economics*, 50(5): 555-566. DOI: https://doi.org/10.1111/agec.12509.

Green J., Laffont J.-J. (1977). On the revelation of preferences for public goods. *Journal of Public Economics*, 8(1): 79-93. DOI: https://doi.org/10.1016/0047-2727(77)90030-5.

Gujarati D. (2014). *Econometrics by Example*. Palgrave Macmillan, London.

Hansmann H. (1999). Cooperative firms in theory and practice. *LTA*, 48(4): 387-403.

Hill R.C., Griffiths W.E., Lim G.C. (2018). *Principles of Econometrics* (3rd edition). John Wiley & Sons, New York, USA.

ISMEA (2024). *L'italia del Vino*. Istituto di Servizi per il Mercato Agricolo Alimentare, Roma Italia. https://www.ismeamercati.it/flex/files/1/2/2/D.29f494c9784c9d69e239/SchedaVino_2024_Aprile_2024.pdf.

Jensen M.C., Meckling W.H. (1976). *Theory of the firm: managerial behavior, agency costs, and ownership structure*. In Brunner K. (ed) Economics Social Institutions. Rochester Studies in Economics and Policy Issues (pp. 163-231). Springer, Dordrecht. DOI: https://doi.org/10.1007/978-94-009-9257-3_8.

Koç G., Cennet O. (2024). Cooperative branded food purchasing behaviour: understand the role of consumer social responsibility, trust, and agri-rural ties through theory of planned behaviour. *New Medit*, 4: 135-152. DOI: https://doi.org/10.30682/nm2404i.

Liang Q., Bai R., Jin Z., Fu L. (2023). Big and strong or small and beautiful: effects of organization size on the performance of farmer cooperatives in China. *Agribusiness*, 39(1): 196-213. DOI: https://doi.org/10.1002/agr.21767.

Licciardo F., Fontanari E. (2024). *La cooperazione agricola italiana: Caratteristiche e rilevanza nel comparto agroalimentare, Rapporto di ricerca*, Rete Rurale Nazionale, MASAF, Rome. DOI: https://doi.org/10.5281/zenodo.14161119.

Magni C.A. (2021). Internal rates of return and shareholder value creation. *The Engineering Economist*, 66(4): 279-302. DOI: https://doi.org/10.1080/0013791X.2020.1867679.

Malorgio G., Grazia C., Caracciolo F., De Rosa C. (2013). Determinants of wine-bottling strategic decisions: empirical evidence from the Italian wine industry. In Giraud-Héraud E., Pichery M.-C. (eds) *Wine Economics: Quantitative Studies and Empirical Applications* (pp. 266-296). Palgrave Macmillan, London. DOI: https://doi.org/10.1057/9781137289520_14.

Marques A., Teixeira C.A. (2023). Vine and wine sustainability in a cooperative ecosystem—a review. *Agronomy*, 13(10): 2644. DOI: https://doi.org/10.3390/agronomy13102644.

Martínez-Victoria Mc., Maté-Sanchez-Val M. (2021). Determinants of trade credit financing: a dynamic analysis comparing agri-food cooperatives and non-cooperatives. *Agricultural Finance Review*, 82(5): 890-913. DOI: https://doi.org/10.1108/AFR-09-2021-0126.

Mediobanca (2022). *Il Settore Vinicolo in Italia* (Ed. 2022), Area Studi Mediobanca, Milan.

Mozas-Moral A., Fernández-Uclés D., Medina-Viruel M. J., Bernal-Jurado E. (2021). The role of the SDGs as enhancers of the performance of Spanish wine cooperatives. *Technological Forecasting and Social Change*, 173: 121176. DOI: https://doi.org/10.1016/j.techfore.2021.121176.

Neves E., Dias A., Ferreira M., Henriques C. (2022). Determinants of wine firms' performance: the Iberian case using panel data. *International Journal of Accounting and Information Management*, 30(3): 325-338. DOI: https://doi.org/10.1108/IJAIM-10-2021-0203.

Ortmann G.F., King R.P. (2007). Agricultural cooperatives II: can they facilitate access of small-scale farmers in South Africa to input and product markets? *Agrekon*, 46(2): 219-244. DOI: https://doi.org/10.1080/03031853.2007.9523769.

Pliakoura A.P., Beligiannis G., Kontogeorgos A. (2021). Significant barriers to the adoption of the agricultural cooperative model of entrepreneurship: a literature review. *International Journal of Social Economics*, 49(1): 1-20. DOI: https://doi.org/10.1108/IJSE-10-2020-0710.

Pokharel K.P., Regmi M., Featherstone A.M., Archer D.W. (2019). Examining the financial performance of agricultural cooperatives in the USA. *Agricultural Finance Review*, 79(2): 271-282. DOI: https://doi.org/10.1108/AFR-11-2017-0103.

Pomarici E., Corsi A., Mazzarino S., Sardone R. (2021). The Italian wine sector: evolution, structure, competitiveness and future challenges of an enduring leader. *Italian Economic Journal*, 7(2): 259-295. DOI: https://doi.org/10.1007/s40797-021-00144-5.

Prendergast C. (1999). The provision of incentives in firms. *Journal of Economic Literature*, 37(1): 7-63. DOI: https://doi.org/10.1257/jel.37.1.7.

Rebelo J., Caldas J. (2015). The economic role of the Portuguese agricultural cooperatives. *Revista de Economia e Sociologia Rural*, 53: 91-102. DOI: https://doi.org/10.1590/1234-56781806-94790053s01007.

Richter B., Hanf J.H. (2021). Cooperatives in the wine industry: sustainable management practices and digitalisation. *Sustainability*, 13(10): 5543. DOI: https://doi.org/10.3390/su13105543.

Royer J.S. (1999). Cooperative organizational strategies: a neo-institutional digest. *Journal of Cooperatives*, 14: 44-67. DOI: https://doi.org/10.22004/ag.econ.46367.

Royer J.S. (2014). The neoclassical theory of cooperatives: part I. *Journal of Cooperatives*, 28: 1-19. DOI: https://doi.org/10.22004/ag.econ.244008.

Sala-Ríos M. (2024). What are the determinants affecting cooperatives' profitability? Evidence from Spain. *Annals of Public and Cooperative Economics*, 95(1): 85-111. DOI: https://doi.org/10.1111/apce.12423.

Schamel G. (2018). Guest editor's introduction to the symposium: organization and performance of cooperative firms in the wine sector. *Journal of Wine Economics*, 13(3): 260-262. DOI: https://doi.org/10.1017/jwe.2018.33.

Schamel G.H. (2014). Wine quality, reputation, denominations: how cooperatives and private wineries compete? *BIO Web of Conferences*, 3: 03008. DOI: https://doi.org/10.1051/bioconf/20140303008.

Staatz J.M. (1987). Farmers' incentives to take collective action via cooperatives: a transaction cost approach. In Royer J.S. (eds) *Cooperative Theory: New Approaches* (pp. 87-107). U.S. Department of Agriculture, Washington, D.C., USA.

Tessitore A. (1990). *Imprenditorialità e cooperazione*. Giuffré, Milan.

Troiano S., Rizzi L., Marangon F. (2023). Social or environmental consciousness? Exploring the consumption of cooperative wines among European citizens. *Wine Economics and Policy*, 12(2): 69-84. DOI: https://doi.org/10.36253/wep-14241.

Verbeek M. (2004). *A guide to modern econometrics (2nd edition)*. John Wiley & Sons, Chichester.

Wooldridge J.M. (2016). *Introductory Econometrics: A Modern Approach* (6th edition). Cengage Learning, Toronto.

Yen M.-F., Li Y.-Y., Miranda M. (2025). Leverage, liquidity, and agricultural cooperative profitability. *International Advances in Economic Research*, 31(1): 45-60. DOI: https://doi.org/10.1007/s11294-025-09930-8.

List of Reviewers 2025

1. Andrea Povellato – CREA PB, Roma, Italy – 0000-0002-6980-4862
2. Filippo Brun – University of Turin, Italy – 0000-0001-5042-1469
3. Luca Mulazzani – University of Bologna, Italy – 0000-0003-2336-9399
4. Achille Amatucci – University of Brescia, Italy – 0009-0000-3257-2749
5. Lena Shaller – BOKU University, Vienna, Austria – 0000-0002-8313-8798
6. Davide Marino – University of Molise, Italy – 0000-0003-2471-6612
7. Bernard Pecqueur – PACTE – Université de Grenoble, France – 0000-0002-4986-0349
8. Serena Tarangioli – CREA PB, Roma, Italy – 0000-0002-8794-1537
9. Bettina Boch – Groningen University, Netherlands – 0000-0001-8108-7766
10. Patrizia Pugliese – Mediterranean Agronomic Institute of Bari, Italy 0000-0001-6753-7804
11. Ruth McAreavey – Newcastle University, England – 0000-0002-9929-4461
12. Giovanni Dara Guccione – CREA PB, Roma, Italy – 0000-0003-1883-0574
13. Roberto Henke – CREA PB, Roma, Italy – 0000-0003-1677-0387
14. Teresa Del Giudice – University of Naples Federico II, Italy – 0000-0001-9417-7816
15. Kim Chang-Gil – Seoul National University, Korea – 0000-0001-5291-9930
16. Marcello De Rosa – University of Cassino and Southern Lazio, Italy – 0000-0002-5053-6861
17. Giuseppe Di Vita – University of Turin, Italy – 0000-0001-6491-2875
18. Raffaele Zanchini – Istituto Arturo Prever, Turin, Italy – 0000-0002-7315-3126
19. Caterina Contini – University of Florence, Italy – 0000-0003-0626-574X
20. Luigi Mastronardi – University of Molise, Italy – 0000-0001-6012-2964
21. François Casabianca – INRAE, Paris, France – 0000-0003-3381-6236
22. Giampiero Mazzocchi – CREA PB, Roma, Italy – 0000-0003-0026-4746
23. Geremia Gios – University of Trento, Italy – 0000-0003-0855-0130
24. Maria Trentinaglia – University of Milan – 0000-0001-7988-2429
25. Roland Condor – EM Normandie Business School, France – 0000-0003-0353-3788
26. Cristina Salvioni – University of Chieti, Italy – 0000-0002-8065-9248
27. Adele Coppola – University of Basilicata, Italy – 0000-0002-9201-7859
28. Franco Sotte – Agriregionieuropa, Ancona, Italy – 0000-0001-5940-2213
29. Flavio Lupia – CREA PB, Roma, Italy – 0000-0002-8379-9713
30. George Papadopoulos – University of Athens, Greece – 0000-0002-5442-1711
31. Francesco Vanni – CREA PB, Roma, Italy – 0000-0003-4009-3013
32. Alberto Bernués – Centro de Investigación y Tecnología Agroalimentaria de Aragón (CITA), Spain – 0000-0002-3237-9751
33. Luca Bartoli – Unversity of Cassino, Italy – 0000-0002-7048-1589
34. Carolina Perpiña Castillo – European Commission, ISPRA, Italy – 0000-0002-3161-2240
35. Roberto Cagliero – CREA PB, Torino, Italy – 0000-0002-9038-3038
36. Alan Matthews – School of Social Sciences and Philosophy at Trinity College Dublin, Ireland – 0000-0003-1051-1499
37. Eugenio Pomarici – University of of Padua, Italy – 0000-0002-3166-7997
38. Antonio Seccia – University of Foggia, Italy – 0000-0003-4549-6479
39. Fabian Capitanio – University of Naples Federico II, Italy – 0000-0003-0327-8019
40. Roberto Solazzo – CREA PB, Roma, Italy – 0000-0003-1445-6044
41. Rui Manuel De Sousa Fragoso – University of Evora, Portugal – 0000-0002-0531-5365
42. Angelo Frascarelli – University of Perugia, Italy – 0000-0002-8910-7044
43. Andrea Pufahl – Institute of Rural Studies, Braunschweig, Germany – 0009-0007-8773-4371

Italian Review of Agricultural Economics Vol. 80, n. 3: 131-132, 2025
ISSN 0035-6190 (print) | ISSN 2281-1559 (online)

44. Ilona Rac – University of Ljubljana, Slovenia – 0000-0003-4344-267X
45. Francesco Pagliacci – University of Padua, Italy – 0000-0002-3667-7115
46. Federica Viganò – Free University of Bozen-Bolzano, Italy – 0000-0002-0406-1463
47. Roberta Sardone – CREA PB, Roma, Italy – 0000-0001-7650-6102
48. Gianpiero Fumi – Università Cattolica del Sacro Cuore, Milano, Italy – 0000-0002-8107-3505
49. Brenda Robles – University of Rovira i Virgili, Tarragona, Spain – 0000-0001-6023-7809
50. Giorgio Osti – University of Padua, Italy – 0000-0002-6014-3113
51. Alessio Cavicchi – University of Pisa, Italy – 0000-0002-7793-865X

The Italian Review of Agricultural Economics is published through collaboration between CREA (Council for Agricultural Research and Economics) and SIDEA (Italian Association of Agricultural Economics). The REA is a scientific journal released every four months, focusing on articles covering economics and policies related to agriculture, forestry, the environment, the agro-food sector, and rural sociology. All articles undergo a double-blind peer review process.

REA adheres to the DORA principles

Signatory of DORA