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Designing an Innovation-Oriented Cluster Model for the Agri-Food Sector in Greece: A Multi-Level Framework with Application to the Wine Industry

Ramzi Alinsaoui[1*], Adnan Shehadeh[1], Panagiotis Tataridis[1], Ioannis Katsanakis[2], Angelos Kotios[2]

[1]Department of Wine, Vine and Beverage Sciences, University of West Attica, Egaleo, Greece
[2]Department of Tourism Studies, School of Economics, Business & International Studies, University of Piraeus, Piraeus, Greece
Email: *ralinsawi@uniwa.gr

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Abstract

A cluster is defined as a geographically proximate group of complementary and interrelated firms and institutions, connected through value chains and knowledge flows, and benefiting from shared infrastructure, suppliers, and markets. This study explores the role of business clusters as drivers of regional innovation and competitiveness, emphasizing their capacity to enhance efficiency, knowledge exchange, and institutional collaboration. Focusing on the Greek agri-food sector, it addresses the absence of integrated, multi-level models for innovation-oriented collaborative clusters. The paper aims to: 1) develop a theoretical framework for such clusters and 2) propose an applied governance and operation model for pilot implementation. To validate the model, three Greek regions: Epirus, Attica, and Crete are comparatively analyzed, capturing spatial, socio-economic, and productive diversity. The findings reveal differentiated regional development patterns and collaborative dynamics, offering valuable insights for designing a flexible and adaptive cluster-based policy framework, with the wine industry serving as a pilot application.

Keywords

Collaborative Clusters, Innovation-Oriented Networks, Multi-Level Model, Agri-Food Sector, Competitiveness, Coopetition, Regional Innovation, Sustainable Development

1. Introduction

Clusters represent a significant economic phenomenon situated within a competitive environment, in which multiple firms simultaneously compete and collaborate to achieve distinct economic advantages. They constitute a structured form of cooperation among businesses and other stakeholders such as research institutions, governmental agencies, and service providers, aiming to foster innovation, facilitate knowledge exchange, and enhance overall competitiveness. By integrating complementary resources and capabilities, clusters enable participating actors to benefit from collective learning, shared infrastructures, and coordinated access to suppliers and clients, thereby creating both local and global economic value. In this context, clusters serve not only as mechanisms for enhancing sectoral productivity but also as strategic platforms that promote technological development, innovation-driven growth, and sustainable economic performance (Porter, 1998; Delgado et al., 2016).

Collaborative clusters, internationally known as clusters, represent a key mechanism for enhancing innovation and competitiveness. Through the interconnection of firms and other stakeholders, clusters promote knowledge exchange, the efficient use of shared resources, and the development of collective capabilities, thereby contributing to increased productivity and strengthened economic dynamics (Horzela-Miś, 2024).

Greek enterprises currently face diminished competitiveness relative to their European counterparts due to accumulated debt, high energy costs, constrained access to bank financing, and the repercussions of geopolitical conflicts, including the wars in Ukraine and the Middle East. Firms in the primary production sector additionally confront the impacts of climate change on agricultural output, necessitating adaptation to an increasingly adverse global economic environment and an uncertain future (Makantasi & Valentis, 2024; IMF, 2024). The majority of Greek enterprises are Small and Medium-Sized Enterprises (SMEs), often lacking the organizational and managerial structures, technological capabilities, and financial resources required to navigate current economic challenges and sustain operations at both national and international levels. As a result, these enterprises are compelled to compete with other European firms while pursuing growth within a highly demanding global business context.

Although SMEs form the backbone of most national economies, they face intense competition and significant pressures due to their limited scale and the localized nature of production and distribution. In Greece, SMEs account for 99.9% of non-financial sector enterprises (excluding fisheries, agriculture, forestry, and certain service sectors such as education and healthcare), represent 84.6% of total employment, and contribute 67% of Gross Value Added (GVA), thereby constituting the foundation of the country's economic activity and entrepreneurial landscape (Alpha Bank, n.d.; Business News, 2024).

In the context of rising global competition, enterprise survival and success increasingly depend on the capacity to innovate. A significant and effective strategy

to address these challenges lies in leveraging the entrepreneurial potential of Greek firms to grow through innovation and strategic cooperation. This may involve the development of new products or services that differentiate them from competitors or the enhancement of existing offerings by strategically utilizing competitive strengths (Bartlett & Ghoshal, 1990; Rothaermel, 2008; Chesbrough, 2020).

In this framework, collaboration between academic and research institutions (knowledge base), SMEs (business environment), and state support (financing and facilitation of cooperation) establishes new conditions for competitiveness and sustainable development, thereby enhancing enterprise survival. This tripartite collaboration model, commonly referred to as the "Triple Helix model", encompassing government, academic/research institutions, and enterprises, serves as a critical strategic instrument for implementing horizontal policies aimed at stimulating local economies and redefining regional development trajectories (Etzkowitz & Leydesdorff, 2000).

Specifically, within the Greek agri-food sector, clusters provide a mechanism to leverage endogenous development resources and foster cooperation among businesses, research institutions, and public organizations. The development of such clusters confers significant advantages, including the promotion of innovation, enhanced competitiveness, and the adoption of sustainable practices. Due to the small scale of most Greek firms, the creation of business resources such as specialized personnel, increased production capacity, access to investment financing, and the diversification of products and services is constrained. This scarcity of essential resources necessitates differentiated development strategies guided by specific strategic trends (Zaridis, 2020; Koutouzidou, 2022).

When small Greek enterprises are unable, due to their limited size and resources, to compete on equal terms with larger firms or multinational corporations, conditions arise that encourage collaboration to achieve economies of scale. Horizontal networks, for instance, unite similar firms to implement joint procurement, adopt best practices, and coordinate sales efforts, thereby enhancing operational efficiency and collective competitiveness.

Based on these considerations, clusters in Greece are analyzed and compared with successful clusters in Europe and globally to identify similarities and differences. Moreover, Greek cooperatives are examined alongside leading international clusters to evaluate structural, performance, and developmental divergences.

2. Theoretical Background

The concept of clusters has its roots in classical economic theory. Alfred Marshall, in *Principles of Economics* (Marshall, 1890), was the first to use the term clusters to describe the concentration of specialized economic sectors in specific geographical locations, which facilitates efficiency, knowledge spillovers, and local specialization.

Building on this foundation, Michael Porter introduced the modern concept of

collaborative clusters. The prevailing definition of clusters, also referred to as networks or agglomerations, describes the geographical concentration of similar or complementary firms and organizations that maintain open channels for business synergies, transactions, and communication (Porter, 1998). These entities share personnel and infrastructure, collaborate on innovation, and face common business opportunities and threats.

Clusters, as emphasized by both Marshall and Porter, function as dynamic economic ecosystems that enhance competitiveness, foster innovation, and strengthen regional economic development. In particular, they provide a framework for integrating firms, research institutions, and governmental organizations to achieve collective efficiency and knowledge exchange (Delgado et al., 2016).

Collaborative clusters can be classified into three main types:

- **Type A—Horizontal Clusters:** Characterized by strong spatial concentration and local-level production organization, with specialization in specific sectors and labor. They typically involve small firms with high flexibility, enabling rapid adaptation to market changes. Examples: Birmingham Jewelry Quarter; Hackney furniture industry.
- **Type B—Vertical Clusters (Value-Chain Clusters):** Involve both commercial and non-commercial relationships, with stable production links among firms. These clusters often include larger enterprises located outside urban centers and engage in global relations. Examples: Emilia Romagna, northeastern Milan.
- **Type C—Innovation-Oriented Clusters:** Based on trust, high-risk projects, and global-scale operations. These may include small and large firms that rely heavily on human capital. Examples: Silicon Valley (USA), Sophia Antipolis (France) (Zygiaris, 2014).

Recent literature emphasizes additional classifications, including **digital innovation clusters** and **sustainability-driven clusters**, which reflect the influence of digitalization, green transitions, and circular economy frameworks.

3. Advantages of Clusters

The purpose behind the development of clusters today extends beyond collaborative networking among members of a value chain; it also encompasses the concept of open innovation facilitated through these networks. Open innovation has emerged as a core strategy within the knowledge-intensive economy. Chesbrough (2003) emphasizes that the reduction of costs and the more efficient and accelerated entry into global markets have encouraged universities, technological institutes, and enterprises to adopt open innovation models (Chesbrough, 2003; Lee et al., 2010; McPhillips, 2020; Lis et al., 2020).

According to IME/GSEVEE (2015), several advantages of clusters include:

- Encouragement of extroversion and international orientation.
- Strengthening of the economy through the attraction of investment.
- Realization of economies of scale via the joint use of facilities, services, infra-

structure, and resources, leading to reduced production and transportation costs and more efficient supply chains.

- Access to timely and accurate information.
- Improved accessibility to financial institutions, venture capital, and specialized legal services (e.g., intellectual property rights and industrial property protection).
- Creation of favorable conditions for Research and Development (R&D).
- Support for the establishment of new enterprises, particularly through spin-offs.
- Access to specialized personnel.
- Development of social capital.
- Enhancement of operational efficiency.
- Facilitation of knowledge and information diffusion.
- Promotion of collective learning and innovation through the integration of combined knowledge.
- Strengthened capacity to compete with larger and more powerful firms.
- Promotion of local products produced by small-scale producers in specific geographic regions.
- Contribution to reducing unemployment rates.
- Easier access to resources.
- Improved access to basic infrastructure and entry into new markets.
- Opportunities for new businesses seeking expansion.
- A competitive environment that fosters stronger development incentives for firms, institutions, and individuals.
- Geographic concentration of enterprises, resulting in the creation of a labor pool with significant expertise and experience in the cluster's sector.
- Expanded markets with increased opportunities for reaching larger customer bases.
- Enhanced collaboration among cluster members, as geographical proximity fosters trust and facilitates communication.

The specific benefits of clusters may vary depending on the industry or sector of activity. Nevertheless, clusters contribute to the development of a competitive business environment that generates advantages for enterprises, employees, and society at large.

4. Factors Making Greece a Unique Context for the Development of Regional Agri-Food Collaborative Clusters (CCs)

1) Small and Medium-Sized Enterprises (SMEs): SMEs constitute the main pillar of entrepreneurship and the economy in Greece, representing between 99.8% and 99.9% of all enterprises. They cover the entire spectrum of productive activities and sectors and possess distinctive capabilities.

2) Soil Fertility and Biodiversity: The nature of Greece's fertile land and its

biodiversity position Greek products among the highest quality globally, conferring strong competitive advantages.

3) Geography and Climate: Greece's geographical location in the Mediterranean Sea makes it one of Europe's most significant producers of agricultural products. Its climate and natural resources enable the cultivation of a wide range and variety of crops.

4) Cultural Heritage: Greece has a long-standing history in agriculture and food production, with traditions and practices that influence both the methods of production and consumption of food.

5) Environmental Protection: The preservation of the natural environment, along with the safeguarding of traditional agricultural practices and biodiversity, are critical factors influencing agricultural development and food policy within the European Union.

6) Economic Dependence: The Greek economy relies heavily on agriculture and tourism, which present specific challenges and opportunities for the agri-food sector (Krokidis, 2023).

5. Methodology

The methodological framework of this study integrates a systematic literature review with empirical data collection and comparative analysis, ensuring methodological triangulation and enhancing the validity of findings. The research adopted a multi-stage design to investigate the role of clusters and agri-food cooperatives within the Greek economic context.

The first stage involved a comprehensive review of Greek and international literature. An initial set of 60 publications was retrieved from reputable databases, including Google Scholar, PLOS ONE, PubMed, and ScienceDirect. Applying predefined inclusion criteria, the sample was refined to 40 studies focusing on key dimensions such as cluster definitions, characteristics, models, advantages and limitations, composition, typologies, funding sources, and impacts. Covering the period 2006-2024, the review facilitated an understanding of temporal evolution, developmental dynamics, and economic implications of clusters. The analysis identified essential characteristics and models while revealing the absence of universally accepted frameworks suitable for the Greek context and highlighting gaps in digitalization, eco-innovation, and social innovation in agri-food clusters.

Building upon the theoretical insights, the second stage employed two structured questionnaires to collect primary data from key stakeholders in Greek clusters and agri-food cooperatives. Sample selection was guided by three criteria: inclusion of executives in managerial and strategic positions to ensure informed responses regarding organizational and operational practices; representation of active clusters and cooperatives across diverse geographic regions to maximize coverage; and preliminary telephone outreach to confirm willingness to participate. The first questionnaire, targeting clusters, included 41 questions across nine the-

matic sections addressing characteristics, organizational and operational models, and cluster classifications. The second questionnaire, targeting agri-food cooperatives, comprised 28 questions across eight thematic sections aimed at mapping structural and functional attributes and assessing potential for evolution into innovation-oriented cluster formations. Questionnaires were distributed in March 2024, with 24 of 47 clusters responding and 65 of 503 cooperatives participating, ensuring a sufficiently diverse and experienced participant pool for reliable analysis.

6. Results

The following points provide a concise synthesis of the main findings, offering a comprehensive overview of the structural characteristics, operational dynamics and strategic prospects of Greek innovation clusters within the national innovation ecosystem, relevant to the first questionnaire:

1) Awareness and Knowledge Gaps

There is a significant need for increased awareness regarding the advantages and benefits of innovation clusters, both among enterprises and institutional stakeholders.

2) Sectoral Strengths: The Agri-Food Domain

Agri-food clusters in Greece demonstrate higher activity levels than clusters in other sectors, largely due to favorable climatic and geographical conditions and the utilization of high-quality traditional raw materials.

3) Scale and Scope

Greek clusters are generally smaller than their European and global counterparts and exhibit a primarily national focus. Most function is as coordinators rather than incubators, indicating limited capacity for supporting start-up creation or technology transfer.

4) Composition and Participation

Member enterprises are relatively evenly distributed among small, medium, and large firms. However, there is an urgent need to increase the participation of start-ups to promote innovation, enhance competitiveness, and strengthen market positioning.

5) Research and Academic Integration

The integration of universities and research centers into cluster collaborations remains insufficient. Strengthening such partnerships is essential for mutual knowledge exchange, innovation generation, and the development of high-value products.

6) Vision and Governance

The active engagement of members in the common vision of the cluster is critical. Many clusters require enhanced governance mechanisms to encourage commitment and collective goal alignment.

7) International Visibility and Exports

Greek cluster products exhibit limited global recognition, which constrains their competitiveness. Nevertheless, most clusters display an export-oriented profile: 71%

engage with international markets through exports or investments, 21% through the import of personnel or know-how, and 8% through the import of raw materials or components.

8 Geographical Proximity and Collaboration

Geographic proximity, a key success factor in cluster theory, is absent in a considerable share of Greek clusters, reducing their ability to leverage spatial advantages such as trust, shared infrastructure, and efficient communication.

9) Funding and Resource Access

Limited access to financial resources is one of the most critical barriers to competitiveness and sustainability. Additional support through European, national, and private funding mechanisms is urgently required.

10) Innovation and R&D Investment

Innovation activities in product development must be intensified. Greater investment in Research and Development (R&D) and the adoption of new technologies are vital for improving competitiveness and ensuring long-term sustainability.

11) Quality Certification and Standards

Acquiring quality certifications such as ISO 56002, Bronze Label, Silver Label, and Gold Label enhances consumer trust, increases market credibility, and improves profitability.

12) Digital Transformation

The digitalization of operations and the adoption of advanced technologies provide Greek enterprises with a strategic advantage, improving efficiency and integration with global value chains.

13) Human Capital

Human resources are a fundamental factor for the creation, operation, and survival of clusters. Investing in skills development and talent retention directly enhances productivity and innovation capacity.

14) Policy Framework and Institutional Support

The Greek government must establish a coherent policy framework to support the creation, coordination, and growth of clusters, aligning national initiatives with European cluster policies.

15) Framework, Consistent with European and International Standards

This structure facilitates cooperation and trust among members.

16) Strategic Implications for the Agri-Food Sector

The empirical analysis underscores the urgent need to institutionalize and implement an effective innovation cluster model within Greece's agri-food sector. Such a model is a prerequisite for enhancing competitiveness and achieving sustainable regional development.

Main Findings from the Analysis of the Second Questionnaire (Agricultural Cooperatives in Greece): The key findings from the analysis and processing of the responses collected from agricultural cooperatives in Greece are summarized as follows:

1) Governance & Participation

- The majority of agri-food cooperatives have been operational for several years, demonstrating sustained experience and stability within the sector.
- Cooperatives exhibit a variety of legal forms, reflecting institutional diversity and adaptability.
- Cooperatives operate across multiple regional levels, demonstrating broad geographic distribution.
- Most cooperative management personnel report satisfaction with the services provided, indicating effective operations and high levels of trust.
- Approximately half of the respondents consider the information dissemination, monitoring, and decision-making systems within cooperatives to be adequately organized.
- Most members support the cooperative's common vision to a high or very high degree, reflecting strong commitment, although additional efforts are required to engage all members equally.
- Member engagement in social activities and community initiatives could be further promoted.
- The agri-food sector represents the largest cooperative domain in Greece, accounting for approximately 66% of all cooperatives.

2) Innovation & R&D

- There is significant potential to enhance collaboration between cooperatives and research or educational institutions, which could promote innovation and improve operational efficiency.
- Findings suggest that cooperatives focus on member empowerment by fostering collaboration, innovation, and market competitiveness.
- Growth and long-term viability are primary priorities, whereas innovation activities generally remain secondary.
- Although cooperatives demonstrate commitment to environmental protection and sustainability, there is potential to further intensify and expand related initiatives.

3) Funding & Resources

- Members' agricultural holdings are relatively small on average.
- Many cooperatives face limited access to external financial resources and rely predominantly on internal funding, highlighting the need to diversify funding sources to ensure long-term sustainability.
- Cooperatives face significant challenges in financing, specialization, know-how, and capacity development, underscoring the need for targeted strategic support measures.
- Stronger state support and intervention are necessary to reinforce cooperatives and enhance their contribution to national economic development.

4) Internationalization & Networking

- Cooperatives play a critical role in enhancing collaboration, safeguarding against competition, and promoting products; however, further improvement is needed in market expansion and access to finance.

- Agricultural cooperatives primarily focus on product exports, while their international activities in other domains remain limited.
- There is considerable scope to strengthen their international presence and competitiveness.
- The main priorities of cooperatives focus on product promotion and securing a competitive advantage in the market.

The collected data were systematically processed and analyzed using Qualitative Comparative Analysis (QCA), a method particularly suited to detecting causal patterns and commonalities across complex socio-economic systems. Comparative evaluation of the findings revealed both convergences and divergences between clusters and cooperatives, offering valuable insights into their structures, dynamics, and viability. This integrated methodological approach, combining literature review, empirical investigation, and comparative analysis, provided a robust theoretical and empirical foundation for deriving conclusions and formulating policy recommendations regarding the role of clusters and cooperatives in the Greek economic context.

7. Discussion and Policy Implications

The empirical analysis of Greek innovation clusters and agri-food cooperatives elucidates a complex, interdependent innovation ecosystem characterized by both latent potential and structural constraints. Clusters and cooperatives operate as complementary mechanisms: clusters predominantly facilitate knowledge-intensive innovation, technology transfer, and market expansion, whereas cooperatives reinforce localized collaboration, member engagement, and operational resilience. Recognizing these synergies is essential for developing evidence-based policies that enhance competitiveness and sustainable regional development (Kalogiannidis et al., 2024; European Cluster Collaboration Platform, 2022).

Clusters and Innovation Dynamics. Greek innovation clusters, particularly in the agri-food sector, benefit from advantageous climatic and geographic conditions, alongside high-quality traditional raw materials. Nevertheless, their generally modest size, primarily national orientation, and limited capacity for start-up incubation and technology commercialization constrain their international competitiveness. Addressing these limitations requires targeted policy interventions, including enhanced integration with academic and research institutions, fostering entrepreneurial participation, and strategic promotion to global markets (Agro-Labs Project, n.d.; Horizon Europe, 2023). Strengthening governance frameworks and cultivating active stakeholder engagement are equally critical to ensuring alignment with collective objectives and long-term sustainability (European Commission, n.d.).

Cooperatives as Catalysts for Regional Development. Agricultural cooperatives complement cluster dynamics by emphasizing collective decision-making, collaborative practices, and member-oriented operational strategies. Their broad geographical presence and institutional diversity create a robust foundation for

localized development. However, challenges persist, including restricted access to external financing, limited investment in innovation, and underdeveloped international networks. Strategic partnerships with universities, research centers, and other cooperatives can amplify knowledge transfer, operational efficiency, and innovation potential. Furthermore, cooperatives' commitment to environmental sustainability and social engagement aligns with EU strategies such as the European Green Deal and Farm to Fork Strategy, providing opportunities for integrated regional development (Kalogiannidis et al., 2024; University of Wisconsin-Madison Extension, n.d.).

Policy and Institutional Considerations. Findings underscore the necessity of coherent national policy frameworks that simultaneously support clusters and cooperatives. Key priorities include:

1) Facilitating access to diverse financial instruments and funding programs.

2) Promoting digitalization, advanced technologies, and traceability systems to enhance efficiency and global integration.

3) Incentivizing R&D and innovation activities across both organizational forms.

4) Encouraging quality certifications and sustainable practices to strengthen credibility, market positioning, and environmental stewardship.

5) Addressing structural barriers, including disparities in firm capabilities, limited international visibility, and suboptimal spatial clustering, to maximize the benefits of localized collaboration (EU CAP Network, 2025; ECCP, 2022; AgroLabs Project, n.d.).

Strategic Applications. The multi-level framework provides practical avenues for enhancing competitiveness and resilience. Initiatives such as incubators, innovation hubs, and cross-regional partnerships can facilitate start-up creation, accelerate technology transfer, and expand international engagement (ECCP, 2023). Coordinated action between governmental agencies, research institutions, clusters, and cooperatives can foster trust, strategic alignment, and coopetition, ultimately driving regional innovation and sustainable economic growth (Kalogiannidis et al., 2024; Science Business, 2024).

8. Conclusion

Integrating innovation clusters and cooperative networks within a coherent, multi-level policy framework provides a robust foundation for enhancing competitiveness, fostering innovation, and promoting sustainable regional development in the Greek agri-food sector. The empirical findings highlight that both clusters and cooperatives play complementary roles: clusters facilitate knowledge-intensive innovation, market networking, and technology transfer, while cooperatives strengthen localized collaboration, member empowerment, and operational stability. Recognizing these synergies is essential for designing policies that leverage their combined potential.

The flexibility of the proposed model allows for adaptation to regional particularities, enhancing resilience, innovation, and sustainable development across di-

verse local contexts. Furthermore, the model is grounded in international theoretical literature and empirical evidence concerning the structure, functioning, and evolutionary dynamics of clusters, aiming to identify the key factors that influence their sustainability and competitiveness.

Overall, this model seeks to strengthen the Greek agri-food economy by fostering collaborative innovation, enabling SMEs to overcome structural challenges, and embedding sustainability practices aligned with European and global frameworks. Simultaneously, it aligns with the strategic priorities of the European Union, including the European Green Deal and the "Farm to Fork" Strategy.

The model's hierarchical structure encompasses:

- Macro-level: Institutional, geopolitical, and economic factors that shape the national and European innovation environment.
- Meso-level: Regional and sectoral governance, stakeholder interactions, and resource coordination.
- Micro-level: Organizational dynamics of individual clusters and cooperatives, emphasizing partnerships, governance practices, and innovation processes.

The six interdependent subsystems ranging from central productive cores, research and education, and distribution networks, to finance and institutional tools, infrastructure, and collaboration culture collectively enable coordinated action, knowledge sharing, and market competitiveness. For cooperatives, integrating these subsystems supports operational efficiency, member engagement, and sustainable practices, while for clusters, they facilitate innovation, start-up incubation, and internationalization (**Figure 1**).

From a policy perspective, the findings underscore the urgent need to:

- Enhance access to financial resources and funding mechanisms for both clusters and cooperatives.
- Strengthen governance structures and encourage active member participation to align strategic objectives.
- Foster partnerships with research institutions and universities to improve knowledge transfer and innovation capacity.
- Promote digital transformation, traceability systems, and adoption of new technologies to increase efficiency and integration into global value chains.
- Incentivize quality certifications and sustainable practices to boost credibility, market positioning, and environmental responsibility.

The proposed framework enables clusters and cooperatives to operate synergistically, optimizing resource use, facilitating knowledge exchange, and enhancing innovation outcomes. Future research should focus on empirical validation in specific regional contexts to assess long-term effects on innovation performance, competitiveness, and sustainability, thereby informing evidence-based policy and strategic decision-making.

The table and diagram below illustrate the key subsystems that form a multi-level framework supporting innovation-oriented clusters in the agri-food sector. Each subsystem plays a critical role in enhancing productivity, innovation, market

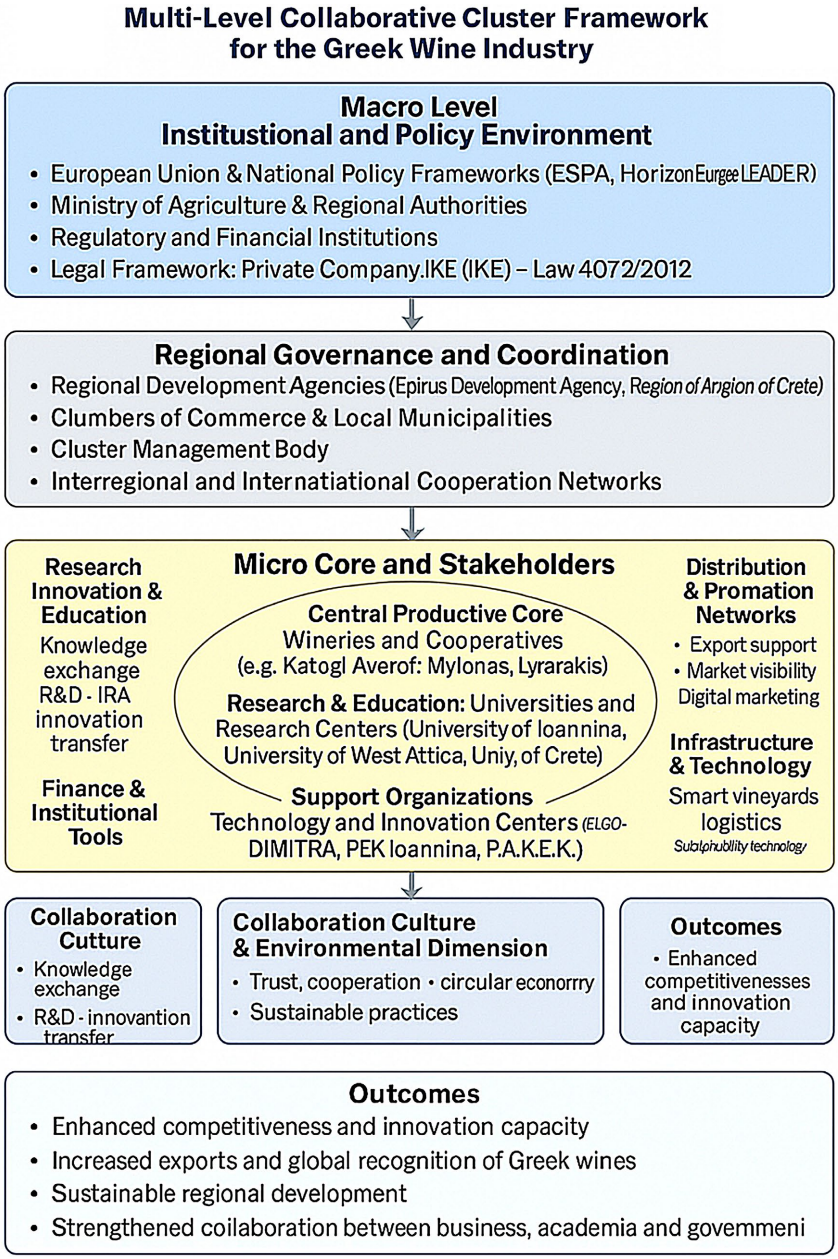

Figure 1. Multi-level collaborative cluster framework for the Greek wine industry.

networking, and sustainable development, contributing collectively to the dynamic and competitive functioning of the agri-food economy (Table 1).

The general theoretical framework is further specified through an application in the winemaking sector, focusing on the unique needs, challenges, and developmental opportunities of three selected Greek regions: Epirus, Attica, and Crete (see **Appendix**). This application leverages local particularities, accounts for institutional and production heterogeneity, and incorporates active participation of key stakeholders, thereby ensuring operational coherence, socio-economic efficiency, and long-term sustainability of the proposed model. Below is a summary of the key findings regarding the winemaking clusters of the three regions.

Table 1. Six Interdependent subsystems.

Six Interdependent Subsystems	
Subsystem	**Function**
A. Central Productive Core	Coordinates core production activities within the cluster
B. Research, Innovation, and Education	Supports knowledge development and technological advancement
C. Distribution and Promotion Networks	Facilitates market access and commercial networking
D. Finance, Policy, and Institutional Tools	Provides regulatory support and funding mechanisms
E. Infrastructure and Technology	Ensures availability of tangible and intangible resources
F. Collaboration Culture and Environmental Dimension	Promotes trust, social cohesion, and sustainable practices

Multi-Level Model of Innovation-Oriented Clusters: A schematic representation of hierarchical levels and subsystems for strengthening the agri-food economy.

Epirus Region

Epirus, with its mountainous terrain and diverse microclimates, provides ideal conditions for producing high-quality wines. The main varieties include indigenous grapes such as Debina, Vlahiko and Xinomavro, as well as international ones like Chardonnay, Cabernet Sauvignon, and Syrah. The strategic objectives of the cluster could focus on fostering collaboration among wineries, research institutions and tourism enterprises, promoting local wines nationally and internationally and participating in exhibitions such as ProWein and Vinitaly. Key stakeholders could include the University of Ioannina, the Chamber of Commerce of Ioannina, the Epirus Development Agency, and wineries such as Katogi Averof, Ktima Glinavos, and ZOINOS (Zitsa) S.A. The cluster could operate as a Private Company (IKE) under Greek Law 4072/2012, benefiting from funding through ESPA, Horizon Europe, and LEADER. Wine tourism is promoted through thematic routes, tastings, and events that combine wine with the region's cultural and natural heritage through the established Wine Roads or Epirus under the Winemakers of North Greece Association (ENOABE) and their Wine Routes Northern Greece initiative.

Attica Region

Attica has a long-standing winemaking tradition and a favorable climate for cultivating both Greek and international grape varieties, including Savvatiano, Agiorgitiko, Assyrtiko, Chardonnay, Merlot, and Syrah. The cluster's strategic goals could be to enhance quality, innovation, and outward orientation, while developing wine tourism through integrated cultural and gastronomic experiences. Its infrastructure could include academic and research institutions such as the University of West Attica and the Agricultural University of Athens, as well as organiza-

tions like ELGO-DIMITRA. Participating wineries could include members of the Wine Producers Association of Attica, such as Mylonas Micro Winery, Gikas Winery, Lepouris Winery, Aoton Winery, Markos Vineyards, Nikolou Winery and others. The legal structure, as in Epirus, could be Private Company (IKE), enabling flexibility and transparency. Funding could come from national and EU programs (ESPA, Horizon Europe), supporting technology, innovation, and international promotion. The tourism and promotion strategy includes thematic festivals, wine tastings, educational programs, and digital campaigns that enhance the Attica wine identity.

Crete Region

Crete's diverse topography and Mediterranean climate with mild winters and dry summers make it ideal for viticulture. The island cultivates indigenous varieties such as Vilana, Kotsifali, Mandilari, Liatiko, and Thrapsathiri, alongside international ones like Chardonnay, Merlot, and Cabernet Sauvignon. The cluster's main objectives could be to foster collaboration among producers, research bodies, and tourism enterprises, to build a unified brand identity, and to strengthen international presence through participation in global events such as ProWein and Vinitaly. Its key institutions include the University of Crete and the Technical University of Crete, as well as regional authorities, development agencies, and prominent wineries of the Wines of Crete network, such as Douloufakis, Karavitakis, Lyrarakis, Manousakis, Minos/Miliarakis and others. The legal form can also be a Private Company (IKE), and funding sources can include ESPA, Horizon Europe, and LEADER. Emphasis is placed on sustainability initiatives, including organic cultivation, smart vineyards, and the development of new grape varieties. Wine tourism is a core pillar, supported by wine routes, festivals, and cultural experiences that showcase the island's unique identity.

Overall, these three regional clusters could combine innovation, collaboration, and sustainability, leveraging local identity and European funding opportunities to strengthen the global competitiveness and recognition of Greek wine.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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Appendix

1. Epirus Region: Regional Cooperative Formation of Innovation with Competitiveness and Sustainability Potential-Winemaking Cluster Analysis

1.1. Geographical and Climatic Characteristics

- Epirus is characterized by mountainous terrain and diverse microclimates.
- Mild climatic conditions are ideal for producing wines of various styles and high quality.
- Key locations: Ioannina, Arta, Preveza, Thesprotia, each presenting unique microclimates and soil compositions.

1.2. Local and International Varieties

- Indigenous: Debina (white), Vlahiko (red), Bekari (red), Xinomavro (red), Malagouzia (white).
- International:
  - White: Chardonnay, Riesling, Sauvignon Blanc, Traminer, Carignan, Grenache Blanc, Malvasia di Candia Aromatica, Maccabeu, Roussanne, Sylvaner, Ugni Blanc (Trebbiano), Viognier.
  - Red: Cabernet Sauvignon, Cabernet Franc, Merlot, Syrah, Grenache Rouge, Alicante Bouschet, Mourvedre, Pinot Noir.
  - Pink skinned: Gewurztraminer.

1.3. Cluster Strategic Objectives

The cluster's strategic objectives may centre on enhancing structured collaboration among wineries, research institutions, and tourism enterprises; strengthening the national and international positioning of local wines through targeted promotion initiatives; and ensuring active participation in major industry exhibitions, including ProWein and Vinitaly, to expand market visibility and facilitate knowledge exchange.

1.4. Infrastructure and Stakeholders

- **Academic Institutions:**
  - University of Ioannina: Department of Agriculture (Viticulture/Oenology), Department of Chemistry (Food Chemistry).
  - Epirus Research and Technology Center, PEK University of Ioannina.
- **Public and Development Agencies:**
  - Chamber of Commerce of Ioannina.
  - 18 Municipalities, Epirus Development Agency (AAEOTA), ETANAM S.A.
- **Private and Cooperative Sector:**
  - Epirus Cooperative Winery "ZOINOS (Zitsa) S.A.".
  - Private wineries, for example: Katogi Averof (Metsovo), Ktima Glinavos (Zitsa/Ioannina), Lambrakis Winery (Tzoumerka/Arta), Markatselis (Fil-

iates/Thesprotia), among others.

- **Northern Greece Wine Producers' Association:** Coordination of producers and product promotion.

1.5. Legal Form

- Private Company (IKE) in accordance with Law 4072/2012.
- Advantages: Limited liability, flexible management, easy entry for new members, transparency, and collaborative governance.

1.6. Funding

- National and European programs: NSRF (ESPA), Horizon Europe, LEADER.
- Support for infrastructure, technology, R&D, innovation, and wine tourism.
- Sustainability initiatives: organic cultivation, smart vineyards, development of new grape varieties.

1.7. Tourism and Promotion

- Development of wine tourism routes, tastings, and festivals.
- Integration with cultural and natural attractions.
- Key wineries: Ktima Vassiliou, Tsantali Winery, Katogi Averof, Ktima Glinavos, Karamolegos Winery.

2. Attica Region: Innovation Collaborative Cluster Promoting Competitiveness and Outward Orientation-Winemaking Cluster Analysis

2.1. Geographical and Climatic Characteristics

- Attica has a long-standing winemaking tradition.
- The region's climate is ideal for cultivating a variety of Greek and international grape varieties.
- Strategically important areas for viticulture include Penteli, Saronic Gulf, and Marathon.

2.2. Local and International Varieties

- Indigenous: Savatiano (white), Agiorgitiko (red), Assyrtiko (white), Moschofilero (white), Roditis (white), Malagousia (white), etc.
- International:
  - White: Chardonnay, Grenache Blanc, Riesling, Grechetto, Greco, Greganico, Maccabeu, Verdicchio Bianco, Viognier, Semillon, Ugni Blanc (Trebbiano).
  - Red: Cabernet Franc, Cabernet Sauvignon, Carignan, Grenache Rouge, Merlot, Refosco, Sauvignon Blanc, Syrah, Aglianico, Pinot Noir, Schioppettino.
  - Pink skinned: Gewurztraminer.

2.3. Cluster Strategic Objectives

The cluster's strategic objectives may be defined as the systematic enhancement

of product quality, innovation capacity, and export orientation, alongside the development of a comprehensive wine-tourism offering grounded in integrated cultural, historical, and gastronomic experiences. This approach aims to position the cluster as a multidimensional regional development mechanism that leverages local heritage while fostering sustainable competitiveness.

2.4. Infrastructure and Stakeholders

- **Academic Institutions:**
  - University of West Attica: Department of Wine, Vine, and Spirits Sciences; Department of Food Science.
  - Agricultural University of Athens: Department of Food Science and Nutrition.
- Research **and Innovation Centers:**
  - P.A.K.E.K.-PaDA, University Research Center of AUA, KEKPA.
  - ELGO-DIMITRA.
- **Public and Development Agencies:**
  - Region of Attica, Municipalities, Chambers of Commerce, development companies.
- **Private and Cooperative Sector:** i.e., members of Wine Producers Association of Attica and cooperatives of the Central Union of Vine and Wine Producing Cooperative Organisations of Greece.
  - Local wineries and cooperatives for example George & Anne Kokotos (Stamata), Vassilis Papagiannakos (Markopoulo), Mylonas Micro Winery (Keratea), Gikas Winery (Spata), Liepouris Winery (Keratea), Aoton Winery (Peania), Sotiris Ginis (Peania), Nikolou Winery (Koropi), Vasilis Markou Vineyards (Peania), Kokotos Estate (Stamata), Gigandis Winery (Marathonios), and others.

2.5. Legal Form

- Private Company (IKE) under Law 4072/2012.
- Advantages: Limited liability, management flexibility, ease of integrating new members, transparency.

2.6. Funding

- National and European programs: NSRF (ESPA), Horizon Europe.
- Support for infrastructure, technology, research, innovation, and outward orientation.
- Development of wine tourism, establishment of visitor centers, and organization of events.

2.7. Tourism and Promotion

- Comprehensive wine tourism packages integrating cultural and gastronomic elements.

- Thematic festivals, wine tastings, educational and experiential programs.
- Promotion of local varieties at national and international levels.
- Integration with existing tourism infrastructure and cultural attractions.

3. Crete Region: Sustainable and Innovation-Driven Wine Cluster with International Orientation-Winemaking Cluster Analysis

3.1. Geographical and Climatic Characteristics

- Crete features a diverse topography, ranging from mountainous areas to coastal plains.
- The island enjoys a Mediterranean climate with mild winters and warm, dry summers, ideal for high-quality viticulture.
- Key viticultural areas include Heraklion, Chania, Rethymno, and Lasithi, each with distinct microclimates and soil types suitable for different grape varieties.

3.2. Local and International Varieties

- Indigenous: Vilana (white), Kotsifali (red), Mandilari (red), Liatiko (red), Thrapsathiri (white), Vidiano (White), Dafni (white), Plyto (white), Moschato Spinas (white), Malvazia di Candia Aromatica (white), Asyrtiko (white), etc.
- International:
  - White: Chardonnay, Grenache Blanc, Malvasia di Candia Aromatica, Sauvignon Blanc, Maccabeu, Roussanne, Sylvaner, Ugni Blanc (Trebbiano), Viognier.
  - Red: Cabernet Sauvignon, Carignan, Grenache Rouge, Syrah, Alicante Bouschet, Mourvedre, Merlot,
  - Pink skinned: Gewurztraminer.

3.3. Cluster Strategic Objectives

The cluster's primary objectives may be articulated as the establishment of a cohesive and institutionalised framework for collaboration among producers, research institutions, and tourism enterprises; the development of a coherent and territorially anchored brand identity; and the reinforcement of the cluster's international visibility through sustained engagement in major global industry events, including ProWein and Vinitaly. Collectively, these aims seek to enhance knowledge exchange, promote strategic market positioning, and support the long-term competitiveness of the regional wine ecosystem.

3.4. Infrastructure and Stakeholders

- **Academic Institutions:**
  - University of Crete: Department of Biology, Laboratory of Plant Physiology and Viticulture.
  - Technical University of Crete: Department of Environmental Engineering, Food Technology Laboratory.

- **Public and Development Agencies:**
  - Regional Authority of Crete, Municipalities, Chambers of Commerce, development agencies.
- **Private and Cooperative Sector:** i.e., members of the Wines of Crete network and cooperatives of the Central Union of Vine and Wine Producing Cooperative Organisations of Greece.
  - Local wineries and cooperatives, e.g., Creta Vine Cooperative, and private wineries, such as Douloufakis (Dafnes), Boutari (Archanes), Manolis & Sotiris Lyrarakis (Alagni), Andreas Dourakis (Alikampos), Manousakis (Vatolakkos), Kourkoulou (Rethymno), Manolis Karavitakis (Pontikiana/Chania) among others.
- **Wine Producers Associations:**
  - Coordination of producers, promotion of local products, and quality certification.

3.5. Legal Form

- Private Company (IKE), under Law 4072/2012.
- Advantages: Limited liability, flexible management structure, easy incorporation of new members, transparency, and cooperative governance.

3.6. Funding

- National and European programs: NSRF (ESPA), Horizon Europe, Leader.
- Support for infrastructure, technology, research and development, innovation, and wine tourism.
- Sustainability initiatives: organic viticulture, smart vineyards, development of new grape varieties.

3.7. Tourism and Promotion

- Creation of wine tourism routes, tastings, and wine festivals.
- Integration with cultural and natural attractions to enhance experiential tourism.
- Central wineries for promotion and visitor engagement include Douloufakis, Lyrarakis, Manousakis, and Minos.