



## UNIVERSITY OF BARI ALDO MORO

Department of Soil, Plant and Food Sciences

PhD course in Soil and Food Sciences

XXXVIII Cycle

Academic Discipline AGR01

---

### **Analysis of the socio-economic results of companies in the form of associations and their propensity to introduce innovations in the agri-food sector**

**PhD candidate:**

Adele Annarita Campobasso

**Supervisors:**

Prof. Francesco Bozzo

Dr. Alessandro Petrontino

**Co-Supervisor:**

Dr. Giovanni Tricarico

**Coordinator:**

Prof. Erica Pontonio

---

### **FINAL EXAM 2026**

*Funded by the European Union - Next Generation EU, Mission 4 Component 2 CUP H91I22000480007 Investment 3.3  
Ministerial Decree no. 352 of 9 April 2022 - National Recovery and Resilience Plan. Project: "Analisi dei risultati socioeconomici  
delle imprese in forma associativa e della loro propensione all'introduzione di innovazioni nell'agroalimentare" (approved by the MUR  
and present on the cineca platform and approved by the Academic Board) co-financed by "Leader Società Cooperativa Consortile"*

Alla mia famiglia

## **Acknowledgements**

I would like to start by thanking my supervisors for their valuable guidance during these three years of research and training. I am also sincerely grateful to the internal and external examiners for their time and expertise in evaluating this work. Finally, I want to thank everyone who crossed paths with me, helping to shape who I am today, giving me not only advice, but also smiles.

## **Ringraziamenti**

I miei ringraziamenti vanno innanzitutto ai miei tutor per la preziosa guida con cui mi hanno accompagnato in questi tre anni nel mio percorso di ricerca e formazione. Inoltre, sono sinceramente grata anche agli esaminatori interni ed esterni per il tempo e la competenza dedicati nel valutare questo lavoro. Infine, voglio rivolgere un pensiero di gratitudine a tutti coloro i quali, in questo percorso, hanno incrociato la loro strada alla mia contribuendo a rendermi la persona che sono, regalandomi non solo consigli, ma anche sorrisi.

## Contents

|                                                                                                    |            |
|----------------------------------------------------------------------------------------------------|------------|
| <b>ABSTRACT .....</b>                                                                              | <b>4</b>   |
| <b>SINTESI .....</b>                                                                               | <b>5</b>   |
| <b>GENERAL INTRODUCTION.....</b>                                                                   | <b>6</b>   |
| <b>1. The central challenge and research gap .....</b>                                             | <b>7</b>   |
| <b>2. Research purposes and questions .....</b>                                                    | <b>7</b>   |
| <b>3. Significance and original contribution .....</b>                                             | <b>9</b>   |
| <b>4. Methodological framework .....</b>                                                           | <b>9</b>   |
| <b>5. Thesis structure .....</b>                                                                   | <b>10</b>  |
| <b>CHAPTER 1: Seafood Choice and Consumption Behaviour .....</b>                                   | <b>15</b>  |
| <b>CHAPTER 2: Blockchain Labelled Pasta and Consumer Preferences .....</b>                         | <b>36</b>  |
| <b>CHAPTER 3: Ornamental Plants Perception and Sustainable Nurseries .....</b>                     | <b>52</b>  |
| <b>CHAPTER 4: A Systematic Review of Innovation Adoption in Agri-Food Enterprises .....</b>        | <b>69</b>  |
| <b>GENERAL CONCLUSION .....</b>                                                                    | <b>106</b> |
| <b>1. Recapitulation: Confronting the central challenge .....</b>                                  | <b>107</b> |
| <b>2. From empirical findings to overarching answers.....</b>                                      | <b>107</b> |
| <b>2.1. The quantifiable demand for trust and transparency (addressing RQ1 &amp; RQ2) .....</b>    | <b>107</b> |
| <b>2.2. The centrality of heterogeneity and segmentation (addressing RQ3) .....</b>                | <b>108</b> |
| <b>2.3. Reframing the innovation ecosystem: An integrated view (addressing RQ4 &amp; RQ5).....</b> | <b>108</b> |
| <b>3. Methodological and personal reflections on an Interdisciplinary journey .....</b>            | <b>109</b> |
| <b>4. A roadmap for future inquiry .....</b>                                                       | <b>109</b> |
| <b>5. Conclusive vision .....</b>                                                                  | <b>110</b> |
| <b>Annexe A – Relazione Triennale.....</b>                                                         | <b>111</b> |

## ABSTRACT

**Context:** The global food system faces the dual challenge of ensuring food security and environmental protection. While policies like the European Green Deal promote innovation for sustainability, its success hinges not only on producer adoption but also on consumer acceptance, as market validation is crucial for completing the innovation cycle. A persistent gap exists between consumer attitudes and purchasing behavior, particularly in value-driven markets like Italy, undermining the market signals needed for a sustainable transition.

**Objective:** This PhD thesis aims to directly bridge this gap by integrating supply-side and demand-side perspectives. It seeks to quantify consumer willingness to pay (WTP) for innovative, sustainability-related credence attributes while simultaneously examining the global factors that influence producers' adoption of such innovations.

**Methodology:** This doctoral research employs a multi-method approach. On the demand side, Discrete Choice Experiments (DCE) are applied across three strategic product categories, sea urchin, pasta, and ornamental plants, and analyzed using advanced econometric models (Mixed Logit, Latent Class Analysis, Structural Equation Modelling) to capture preference heterogeneity and psychographic drivers. On the supply side, a systematic review synthesizes global evidence on the economic, institutional, and behavioral factors affecting innovation adoption by agri-food enterprises.

**Main Findings:** The empirical studies reveal that Italian consumers assign significant economic value to specific innovative attributes, such as origin certification for heritage seafood, blockchain-based traceability for mass-market staples, and phytosanitary diagnostics for non-food products. However, preferences are highly heterogeneous, shaped by socio-demographic and psychographic factors. The systematic review identifies key supply-side barriers, including cost constraints, policy misalignment, and knowledge gaps, which frame the consumer findings within the broader innovation ecosystem.

**Implications:** This PhD thesis provides an integrated framework for de-risking sustainable innovation. For producers, it demonstrates clear market value for certified attributes, guiding investment. For policymakers, it offers an empirical basis for designing targeted support mechanisms, such as certification schemes and traceability infrastructure, that align with consumer values. By linking market pull to production-side constraints, this research contributes to a more resilient and sustainable agri-food system where innovation is both adopted and economically rewarded.

## SINTESI

**Contesto:** Il sistema alimentare globale si trova di fronte alla duplice sfida di garantire la sicurezza alimentare e la protezione dell'ambiente. Sebbene politiche come il Green Deal europeo promuovano l'innovazione per la sostenibilità, il suo successo dipende non solo dall'adozione da parte dei produttori, ma anche dall'accettazione da parte dei consumatori, in quanto la convalida del mercato è fondamentale per completare il ciclo dell'innovazione. Esiste un divario persistente tra gli atteggiamenti dei consumatori e il comportamento di acquisto, in particolare in mercati orientati al valore come l'Italia, minando i segnali di mercato necessari per una transizione sostenibile.

**Obiettivo:** Questa tesi di dottorato mira a colmare direttamente questo divario integrando prospettive dal lato dell'offerta e dal lato della domanda. Cerca di quantificare la disponibilità a pagare dei consumatori (WTP) per attributi di credibilità innovativi e legati alla sostenibilità, esaminando contemporaneamente i fattori globali che influenzano l'adozione di tali innovazioni da parte dei produttori.

**Metodologia:** Questa ricerca di dottorato impiega un approccio multi-metodo. Dal lato della domanda, gli esperimenti di scelta discreta (DCE) vengono applicati a tre categorie di prodotti strategici, ricci di mare, pasta e piante ornamentali, e analizzati utilizzando modelli econometrici avanzati (Mixed Logit, Latent Class Analysis, Structural Equation Modelling) per catturare l'eterogeneità delle preferenze e i driver psicografici. Dal lato dell'offerta, una revisione sistematica sintetizza le evidenze globali sui fattori economici, istituzionali e comportamentali che influenzano l'adozione dell'innovazione da parte delle imprese agroalimentari.

**Risultati principali:** Gli studi empirici rivelano che i consumatori italiani attribuiscono un valore economico significativo a specifici attributi innovativi, come la certificazione di origine per i prodotti ittici tradizionali, la tracciabilità basata su blockchain per i prodotti di base del mercato di massa e la diagnostica fitosanitaria per i prodotti non alimentari. Tuttavia, le preferenze sono altamente eterogenee, modellate da fattori socio-demografici e psicografici. La revisione sistematica identifica i principali ostacoli dal lato dell'offerta, tra cui i vincoli di costo, il disallineamento delle politiche e le lacune di conoscenza, che inquadrano i risultati dei consumatori all'interno del più ampio ecosistema dell'innovazione.

**Implicazioni:** Questa tesi di dottorato fornisce un quadro integrato per la riduzione dei rischi dell'innovazione sostenibile. Per i produttori, dimostra un chiaro valore di mercato per gli attributi certificati, guidando gli investimenti. Per i responsabili politici, offre una base empirica per la progettazione di meccanismi di sostegno mirati, come sistemi di certificazione e infrastrutture di tracciabilità, che si allineano con i valori dei consumatori. Collegando l'attrazione del mercato ai vincoli dal lato della produzione, questa ricerca contribuisce a un sistema agroalimentare più resiliente e sostenibile in cui l'innovazione sia adottata e premiata economicamente.

## **GENERAL INTRODUCTION**

## **1. The central challenge and research gap**

Feeding people reliably and protecting the environment are the major challenges of the global food system. The European Green Deal and the UN Sustainable Development Goals constitute the major plans towards these challenges, using innovation, like advanced technologies, eco-friendly farming, and smarter organizational models (European Commission, 2025a, 2025b; UN Food Systems Hub, 2025). These innovations do not always succeed. They depend on: (i) external factors (i.e., cost and policy), (ii) internal factors (i.e., farmers' knowledge and attitudes), and (iii) support systems (i.e., capacity building and networks). In this perspective, making farming more sustainable is not just about having promising ideas, but about making sure the concerned stakeholders are ready, able, and supported to use them. This understanding is based on established theories of innovation adoption, from Rogers' (1962) classical model of diffusion processes to Knickel et al.'s (2009) systemic framework that moved beyond linear models to account for complex interactions among multiple actors and institutional contexts. While economic incentives and social norms strongly influence the adoption of innovation (Rizzo et al., 2023), barriers such as farm size, level of education, market access, and poor public support can block the adoption of innovation (e.g., Serebrennikov et al., 2020; Bilal & Jaghdani, 2024). Addressing these topics requires integrated approaches that consider multilevel interactions within agri-food systems (El Bilali, 2019) and governance frameworks capable of enabling transformative change (Termeer et al., 2017).

Yet, the innovation cycle remains incomplete without market validation. An innovation, whether an agroecologically grown crop or a blockchain-tracked food product, only succeeds if it is ultimately chosen and paid for by the end consumer. End consumers, as active stakeholders and powerful decision-makers who can help drive agroecological transitions and change across the whole system, are often forgotten and merit attention (Mehrabi et al., 2022; Castellini et al., 2025). As noted by Grunert et al. (2004), sustainability is a "credence attribute", meaning its presence cannot be verified by consumers even after purchase, placing immense importance on trust and certification. In fact, it was demonstrated in recent works that certification attributes and trust are mechanisms to overcome information asymmetry for credence goods (Mazzocchi et al., 2019; Schrobback et al., 2023).

In Italy, this dynamic is particularly acute. Italian consumers are increasingly informed and values-driven, expressing strong preferences for credence attributes like local origin, food safety, and environmental sustainability (Cembalo et al., 2013). However, a persistent "attitude-behaviour gap" exists, where stated preferences do not consistently translate into actual purchasing behaviour (Vermeir & Verbeke, 2006; Carrington et al., 2010; Schimmenti et al., 2013). This gap represents a critical failure in the market signal that is essential for rewarding sustainable producers and de-risking their investment in innovation.

This doctoral research addresses that gap directly by analysing consumer acceptance and quantifying the Willingness to Pay (WTP) for innovative credence attributes across three strategically selected sectors: seafood, pasta, and ornamental plants. By linking market demand to innovation adoption, the research aims to contribute to a more resilient and sustainable agri-food system.

## **2. Research purposes and questions**

The overarching purpose of this PhD thesis is to bridge the gap between agricultural innovation adoption and market demand. It does so by eliciting, analysing, and quantifying Italian consumers' preferences and their WTP for specific, innovative credence attributes across three distinct but

strategically chosen product categories: (i) a high-value, wild-harvested seafood product (sea urchin), representing niche, heritage food systems, (ii) a mass-market, processed staple with a strong Italian identity (pasta), representing the potential for technological traceability and (iii) an ornamental plant, representing the non-food agricultural sector and its unique phytosanitary challenges. This multi-sectoral approach allows for a nuanced understanding of how valuation drivers shift across different product types and consumer relationships.

To contextualize these consumer studies within the broader innovation ecosystem, another overarching purpose of this PhD thesis is to provide a macro-level, supply-side perspective by examining the global economic, institutional, behavioural, and structural factors that drive or hinder producers' adoption of sustainable innovations. By linking producer-side constraints with consumer-side valuation, the PhD thesis offers a holistic framework for understanding how market signals can reinforce or challenge the uptake of sustainability-oriented practices. In doing so, it responds to the growing need for integrated, multi-stakeholder approaches to agri-food system transformation.

Consequently, the PhD thesis is guided by the following research questions (RQ):

- RQ1: What are the key credence attributes that influence Italian consumers' choices for seafood, pasta, and ornamental plants?
- RQ2: What is the economic value (WTP) that Italian consumers assign to these attributes?
- RQ3: How do socio-demographic and psychographic factors influence heterogeneity in these preferences?
- RQ4: What are the implications for developing effective market strategies and sustainable policies?
- RQ5: What are the key supply-side factors influencing the adoption of innovation among agri-food enterprises globally, and how can understanding these factors help frame consumer-driven strategies for accelerating sustainable transitions in the agri-food system?

The common thread between these specific objectives is to address the dual-sided analysis of the innovation adoption cycle, explicitly connecting supply-side variables with demand-side validation. In fact, the empirical studies on seafood, pasta, and ornamental plants, in chapters 1, 2 and 3 (Micro-level, Demand-side), are not isolated case studies. They are strategically selected “testbeds” representing different product types (niche heritage, mass-market staple, non-food) and different innovative credence attributes (origin certification, blockchain traceability, phytosanitary diagnostics). Together, they explore how the valuation of sustainability changes across contexts, providing nuanced, sector-specific insights into the market attractiveness for proposed innovation. In addition, the systematic review in chapter 4 (Macro-level, Supply-side) provides the essential counterpart. By synthesizing global factors that hinder or drive producer innovation, it establishes the contextual framework within which consumer preferences operate. It answers why understanding consumers' willingness to pay is crucial, designing strategies that successfully address and overcome specific adoption barriers (e.g., high cost, lack of knowledge, policy gaps).

Therefore, the connection between chapters is both conceptual and methodological. The thesis moves from the general (global supply-side factors) to the specific (Italian consumer preferences across

sectors) and back to the general (integrated implications for policy and strategy). This integrated approach is the thesis's contribution, bridging a persistent research gap.

### **3. Significance and original contribution**

This doctoral research makes a significant and original contribution by bridging the persistent gap between supply-side innovation adoption and demand-side market dynamics in the agri-food system. It does so through a dual approach: a macro-level systematic review of producer adoption factors and a micro-level economic analysis of consumer preferences in Italy. Together, these components offer a holistic framework for understanding of how innovation can be both adopted and rewarded across the value chain.

In terms of theoretical and methodological contribution, the thesis applies a suite of advanced econometric models, including Discrete Choice Experiments (DCE), Mixed Logit, Latent Class Analysis, and Structural Equation Modelling, to capture the complexity of consumer decision-making. This methodological rigor enables the integration of economic valuation with psychological and behavioural insights, advancing interdisciplinary research in agricultural economics and consumer studies.

Concerning the sector-specific insights, by focusing on three strategically selected product categories, certified sea urchin (heritage seafood), blockchain-tracked pasta (mass-market staple), and diagnostically certified ornamental plants (non-food agriculture), the doctoral research generates novel, quantitative evidence on consumer Willingness to Pay (WTP) for under-explored credence attributes. These insights are tailored to the Italian context, where cultural identity, food heritage, and phytosanitary concerns intersect.

Regarding the practical relevance, the findings of this doctoral research offer actionable intelligence for key stakeholders. For producers, they help de-risk investment in sustainability by demonstrating clear market value for certified innovations. For policymakers, the results provide an empirical foundation for designing support mechanisms such as certification schemes and traceability technologies that align with consumer values. This directly responds to the need for locally tailored, multi-stakeholder policies that promote sustainable transitions.

With regard to the integrated ecosystem perspective, the inclusion of a systematic review strengthens the thesis by situating consumer behaviour within the broader innovation ecosystem. It identifies global supply-side drivers and barriers to adoption, framing the consumer analysis as part of a dynamic feedback loop between production and market demand. This integration reinforces the PhD thesis's originality and relevance to both academic and policy audiences.

### **4. Methodological framework**

This doctoral research adopts a multi-layered methodological approach that combines a macro-level systematic review with micro-level empirical modelling, offering a comprehensive lens on the dynamics of innovation adoption and consumer demand in the agri-food system.

At the core of the empirical analysis is the Discrete Choice Experiment (DCE) methodology. Rooted in Lancaster's characteristics theory of value and random utility theory, DCEs present respondents with hypothetical product choices defined by varying combinations of attributes and levels. This enables the estimation of the utility derived from each attribute and the calculation of marginal

Willingness to Pay (WTP). To capture the complexity of consumer behaviour, the thesis employs a suite of advanced econometric models:

- Mixed Logit Models to account for unobserved heterogeneity in preferences across individuals.
- Latent Class Models to identify distinct consumer segments with homogenous preference structures.
- Structural Equation Modelling (SEM) to incorporate psychographic latent variables—such as attitudes, trust, and environmental concern, directly into the choice framework.

Complementing this demand-side analysis, a systematic review of innovation adoption in agri-food enterprises provides the macro-level, supply-side context. This review synthesizes global empirical evidence on the economic, institutional, and behavioural factors that drive or hinder producers' adoption of sustainable innovations. By identifying common barriers such as cost constraints, policy misalignment, and knowledge gaps, it frames the consumer-focused DCE studies within a broader innovation ecosystem.

Together, these methodological components allow this PhD thesis to illustrate the complete cycle of innovation diffusion: from understanding the structural and behavioural constraints faced by producers, to quantifying the market pull exerted by consumers. This integrated approach supports a holistic vision for a sustainable and economically viable agri-food system, where innovation is both adopted and rewarded across the value chain.

This methodological and practical approach was further enriched by direct field experience, including an 18-month stage at LEADER - Società Cooperativa Consortile (promoted by Confcooperative Puglia), dedicated to supporting agri-food cooperatives in their innovation processes, and a 6-month research period at the Agricultural University of Tirana, which provided a valuable international comparative outlook (See Annexe A – *Relazione Triennale*).

## 5. Thesis structure

This cumulative PhD thesis is structured around three core research articles, and one review article each published in international, peer-reviewed journals. The structure follows a logical progression, exploring the consumer valuation of innovation across different facets of the agri-food system.

**Chapter 1:** Seafood Choice and Consumption Behaviour (Published in *Foods*). This chapter explores the value of origin certification and locality in a high-value, heritage seafood product, establishing the foundational methodology.

**Chapter 2:** Blockchain Labelled Pasta and Consumer Preferences (Published in *Frontiers in Sustainable Food Systems*). This chapter investigates the value of technological traceability (Blockchain) and its associated sustainability information, introducing psychographic drivers into the model.

**Chapter 3:** Ornamental Plants Perception and Sustainable Nurseries (Published in *Horticulturae*). This chapter applies the framework to the non-food sector, examining WTP for plant health

diagnostics and sustainable cultivation in the context of a phytosanitary crisis, utilizing market segmentation analysis.

**Chapter 4:** A Systematic Review of Innovation Adoption in Agri-Food Enterprises (Published in *Agriculture*). This chapter provides the macro-level, supply-side context, systematically reviewing the factors that drive or hinder innovation adoption among producers worldwide. It frames the consumer studies within the broader innovation ecosystem.

**General conclusion:** This chapter synthesizes the findings, discusses their collective implications, and provides targeted recommendations for practice and future research.

## References

- Bilal, M., & Jaghdani, T. J. (2024). Barriers to the adoption of multiple agricultural innovations: insights from Bt cotton, wheat seeds, herbicides and no-tillage in Pakistan. *International Journal of Agricultural Sustainability*, 22(1). <https://doi.org/10.1080/14735903.2024.2318934>
- Carrington, M. J., Neville, B. A., & Whitwell, G. J. (2010). Why ethical consumers don't walk their talk: Towards a framework for understanding the gap between the ethical purchase intentions and actual buying behaviour of ethically minded consumers. *Journal of Business Ethics*, 97, 139–158. <https://doi.org/10.1007/s10551-010-0501-6>
- Castellini, G., Romanò, S., Merlino, V. M., Barbera, F., Costamagna, C., Brun, F., & Graffigna, G. (2025). Determinants of consumer and farmer acceptance of new production technologies: a systematic review. *Frontiers in Sustainable Food Systems*, 9. <https://doi.org/10.3389/fsufs.2025.1557974>
- Cembalo, L., Migliore, G., & Schifani, G. (2013). Sustainability and new models of consumption: The solidary purchasing groups in Sicily. *Journal of Agricultural and Environmental Ethics*, 26(1), 281–303. <https://doi.org/10.1007/s10806-011-9360-0>
- El Bilali, H. (2019). The Multi-Level Perspective in Research on Sustainability Transitions in Agriculture and Food Systems: A Systematic Review. *Agriculture*, 9(4), 74. <https://doi.org/10.3390/agriculture9040074>
- European Commission. (2025a). *Farm to Fork Strategy*. [https://food.ec.europa.eu/horizontal-topics/farm-fork-strategy\\_en](https://food.ec.europa.eu/horizontal-topics/farm-fork-strategy_en)
- European Commission. (2025b). *Green Deal Guidance Note: Sustainable Agri-Food Systems*. [https://knowledge4policy.ec.europa.eu/sites/default/files/thematic\\_guidance\\_note\\_agrifood\\_systems.pdf](https://knowledge4policy.ec.europa.eu/sites/default/files/thematic_guidance_note_agrifood_systems.pdf)
- Grunert, K. G., Bredahl, L., & Brunsø, K. (2004). Consumer perception of meat quality and implications for product development in the meat sector—a review. *Meat Science*, 66(2), 259–272. [https://doi.org/10.1016/S0309-1740\(03\)00130-X](https://doi.org/10.1016/S0309-1740(03)00130-X)
- Knickel, K., Brunori, G., Rand, S., & Proost, J. (2009). Towards a Better Conceptual Framework for Innovation Processes in Agriculture and Rural Development: From Linear Models to Systemic

Approaches. *The Journal of Agricultural Education and Extension*, 15(2), 131–146. <https://doi.org/10.1080/13892240902909064>

Mazzocchi, C., Ruggeri, G., & Corsi, S. (2019). Consumers' preferences for biodiversity in vineyards: A choice experiment on wine. *Wine Economics and Policy*, 8(2), 155–164. <https://doi.org/10.1016/j.wep.2019.09.002>

Mehrabi, S., Perez-Mesa, J. C., & Giagnocavo, C. (2022). The role of consumer-citizens and connectedness to nature in the sustainable transition to agroecological food systems: The mediation of innovative business models and a multi-level perspective. *Agriculture*, 12(2), 203. <https://doi.org/10.3390/agriculture12020203>

Rizzo, G., Migliore, G., Schifani, G., & Vecchio, R. (2023). Key factors influencing farmers' adoption of sustainable innovations: A systematic literature review and research agenda. *Organic Agriculture*, 14, 57–84. <https://doi.org/10.1007/s13165-023-00440-7>

Rogers, E. M. (1962). *Diffusion of innovations*. New York. Free Press.

Schimmenti, E., Galati, A., Borsellino, V., Ievoli, C., Lupi, C., & Tinervia, S. (2013). Behaviour of consumers of conventional and organic flowers and ornamental plants in Italy. *Horticultural Science (Prague)*, 40: 162–171. doi: 10.17221/115/2013-HORTSCI.

Schroback, P., Zhang, A., Loechel, B., Ricketts, K., & Ingham, A. (2023). Food Credence Attributes: A Conceptual Framework of Supply Chain Stakeholders, Their Motives, and Mechanisms to Address Information Asymmetry. *Foods*, 12(3), 538. <https://doi.org/10.3390/foods12030538>

Serebrennikov, D., Thorne, F., Kallas, Z., & McCarthy, S. N. (2020). Factors Influencing Adoption of Sustainable Farming Practices in Europe: A Systemic Review of Empirical Literature. *Sustainability*, 12(22), 9719. <https://doi.org/10.3390/su12229719>

Termeer, C. J. A. M., Dewulf, A., & Biesbroek, G. R. (2017). Transformational change: governance interventions for climate change adaptation from a continuous change perspective. *Journal of Environmental Planning and Management*, 60(4), 558–576. <https://doi.org/10.1080/09640568.2016.1168288>

UN Food Systems Hub. (2025). *EU Pathway Towards Sustainable Food Systems Transformation*. <https://www.unfoodsystemshub.org/docs/unfoodsystemslibraries/national-pathways/european-union/european-union-pathway.pdf>

Vermeir, I., & Verbeke, W. (2006). Sustainable Food Consumption: Exploring the Consumer “Attitude – Behavioral Intention” Gap. *Journal of Agricultural and Environmental Ethics*, 19, 169–194. <https://doi.org/10.1007/s10806-005-5485-3>

**CHAPTER 1: Seafood Choice and Consumption Behaviour**  
(Published in *Foods*)

Article

# Seafood Choice and Consumption Behavior: Assessing the Willingness to Pay for an Edible Sea Urchin

Alessandro Petrontino <sup>1,2</sup> , Fabio Madau <sup>3</sup> , Michel Frem <sup>1,2,4,\*</sup> , Vincenzo Fucilli <sup>1,2</sup>, Rossella Bianchi <sup>2</sup>, Adele Annarita Campobasso <sup>2</sup>, Pietro Pulina <sup>3</sup>  and Francesco Bozzo <sup>1,2</sup> 

<sup>1</sup> Department of Soil, Plant and Food Sciences, University of Bari Aldo Moro, Via Amendola 165/A, 70126 Bari, Italy

<sup>2</sup> Sinagri s.r.l., Spin Off of the University of Bari-Aldo Moro, Via Amendola 165/A, 70126 Bari, Italy

<sup>3</sup> Department of Agricultural Sciences, University of Sassari, Viale Italia, 39A, 07100 Sassari, Italy

<sup>4</sup> Lebanese Agricultural Research Institute, El Roumieh Zone, Qleiat, Keserwan, Lebanon

\* Correspondence: mefrem@lari.gov.lb

**Abstract:** Consumers' behavior towards sea urchin and preferences towards their origin certification and place of consumption may condition their market. In this context, the aim of this research was to elicit the preferences and perceptions of Italian sea urchin dishes using a discrete choice experiment (DCE) approach. A field survey of 453 respondents in Apulia (southern Italy) was conducted for this purpose. The DCE revealed that the origin certification of sea urchin provided Apulia's consumers a high utility with a great pleasurable service in restaurants in which this species was served as a principal dish or seasoned with pasta or pizza. The DCE also showed that the consumption utility of sea urchin was related to a greater influence by place of purchase, place of consumption, technique of conservation, appearance, quality label, fishing zone, low price, male buyer, and, finally, medium and high incomes. Furthermore, Apulian consumers were willing to pay EUR 10.53/dish as an overall average for safe and certified sea urchin consumption. Given this, this research may promote the creation of a local sea urchin brand through the adoption of a market policy and a particular regulation related to the certification of origin, enhancing the competitiveness of this marine heritage species.

**Keywords:** choice experiment; *Paracentrotus lividus*; seafood; sea urchins consumption



**Citation:** Petrontino, A.; Madau, F.; Frem, M.; Fucilli, V.; Bianchi, R.; Campobasso, A.A.; Pulina, P.; Bozzo, F. Seafood Choice and Consumption Behavior: Assessing the Willingness to Pay for an Edible Sea Urchin. *Foods* **2023**, *12*, 418. <https://doi.org/10.3390/foods12020418>

Academic Editor: Cristina Calvo-Porrà

Received: 12 December 2022

Revised: 10 January 2023

Accepted: 12 January 2023

Published: 16 January 2023



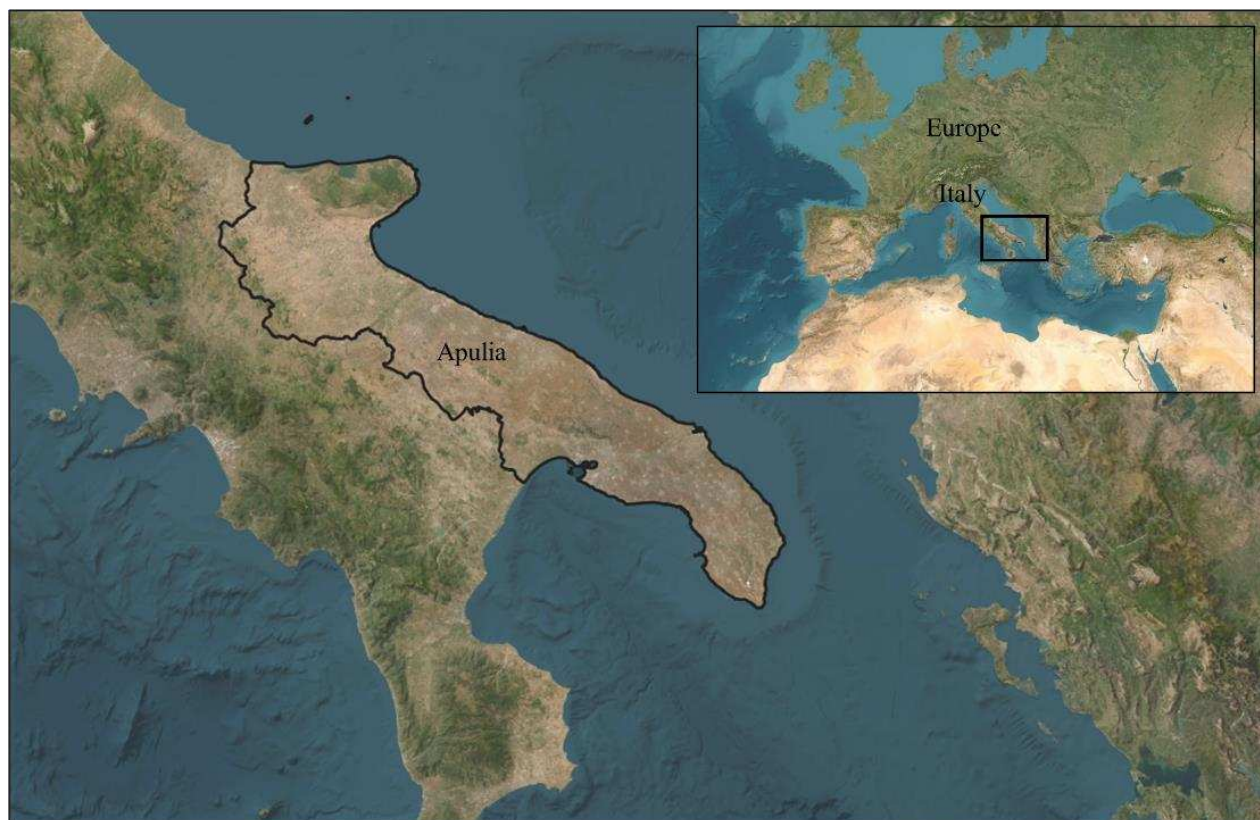
**Copyright:** © 2023 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

## 1. Introduction

### 1.1. Context and Importance

Apulia (southern Italy, Figure 1) is a region that is deeply affected by the presence of the Adriatic Sea. This is also very evident in its typical cuisine and gastronomic restaurants, composed of traditional dishes, many of which are based on fish and seafood such as *Paracentrotus lividus* (Lamarck, 1816, Figure 2), an edible purple sea urchin [1], consumed mainly raw accompanied by bread and wine. This seafood species is very common throughout the Mediterranean Sea and the eastern Atlantic, from Scotland to the Canary Islands. Furthermore, this species holds a very important ecological role, as it helps to regulate the balance of the Mediterranean marine ecosystem [2]. According to the FAO database, the world harvest of sea urchin was estimated to be approximately 63 thousand tons in 2018 [3]. In the European market, Iceland, Spain, France, and Italy constitute the main producer countries. Nevertheless, the latter is one of the main European consumers of sea urchin, with approximately 2000 tons of product consumed every year. At the national level, the regions that are the most active in the collection of *Paracentrotus lividus* are Apulia, Sicily, and Sardinia [4]. Since sea urchin is a product with high commercial value, it is often subject to phenomena of unauthorized harvesting activity. It is important to highlight how Italy, with a production of approximately 107 tons a year, can no longer meet the growing domestic demand; thus, it is forced to import significant shares of sea urchin, especially during the summer season, from nations such as Canada (increase of 294% in recent years),

Chile, or other European trading partners, including France and Spain. In addition, the value that the product assumes is strongly influenced by the state of conservation, the volume of imports, and the methods of processing and storage [3].



**Figure 1.** The European geographic location of the study area—Apulia region (southern Italy). Source: our elaboration.



(a)

**Figure 2.** Cont.



(b)

**Figure 2.** Photos of sea urchin from the Apulia region (southern Italy). *Paracentrotus lividus* (a) is also commonly referred to as the “edible female hedgehog”. The “male” or “black” hedgehogs (b) are none other than species of *Arbacia lixula*. In Puglia, although the same applies to many other Mediterranean countries and to the parts of Spain and France bordering the Atlantic, the hedgehog that is harvested and consumed is the *Paracentrotus lividus*, otherwise called “purple hedgehog” for the widespread presence, in its populations, of specimens whose spines show, precisely, a color tending to violet. Source: photos provided by Meliadò Eleonora, 2021, project “TuGePIAI” funded by the Apulia region (Appendix A).

Users of sea urchin include not only the local inhabitants of the production areas but also tourists, whose demand has played a decisive role both in determining the increase in volumes and in the expanding periods and methods of consumption [5]. The taste of its gonads (the edible part) is appreciated all over the world [1]. Moreover, the semi-finished product obtained from the removal of the gonads, their packaging, and subsequent sterilization in glass containers [6] guarantees greater profitability than the sale of the hedgehog sold for fresh consumption.

### 1.2. Analogous Experimental Literature

Live sea urchins are considered the best quality product on the market. Their price is conditioned by different aspects: quality, origin, species, and organoleptic properties of the gonads. The latter are used for the preparation of numerous dishes, including spaghetti and/or pizzas with sea urchin, mainly when festivals and culinary events are organized according to Apulian popular traditions. When addressing these aspects, it is important to understand what drives consumers to purchase seafood such as sea urchin. In the last two decades, numerous studies have analyzed the factors that influence consumer preferences and calculated the willingness to pay (WTP) by types of seafood and for specific attributes [7–9]. Carlucci et al. [10] explored consumer behavior when buying fish and seafood products in the context of developed countries, highlighting an increasingly selective European consumer, even when it comes to seafood products. Regarding the key attributes of seafood purchasing decisions, a great number of studies have analyzed the importance of origin country, species type, presentation, size, seasonality, color, and price. The marketability of fish products and environmental and animal welfare awareness has been studied through labeling to specify the origin of sea products [11]. In countries such as the United Kingdom (UK), Japan, the United States of America (USA), and Germany, consumers are willing to pay a price premium to buy ecolabeled seafood, but the attributes

“species” and “origin” tip the scales [11,12]. As such, both the literature and market behavior demonstrate how consumer interest in the origin of food, in general [13,14], and seafood, in particular, is gradually growing.

Moreover, other studies have underlined the importance of country-of-origin information in decisions on fish consumption [15–17]. Jaffry et al. [15] indicated that UK consumers preferred home-caught fish over imported fish. Similarly, Claret et al. [16] and Lawley et al. [17] highlighted that consumers preferred locally farmed species to imported equivalent species. Carlucci et al. [10] also confirmed that the country of origin complements ecolabeling as the most important attributes in purchasing and consumption decisions, and Hinkes and Schulze-Ehlers [18] concluded their study on pangasius and tilapia by stating that, overall, the country of origin together with sustainability are relevant factors influencing purchasing decisions, but aspects related to taste and preferences for some fish species could be even more significant in the German context of these seafood products imported from Bangladesh or Vietnam. However, other studies on consumer preferences that have analyzed both country of origin and sustainable production have shown that the country of origin has, on average, a greater effect on consumer preferences than sustainability [19,20].

In addition to the origin attributes, a few studies have investigated consumers’ perception of fish preferences in relation to attributes such as “presentation of the dish” and “place” where it is consumed. Moreover, a few studies have focused on the consumption behavior of sea urchin species. In fact, the purchase consumer behavior of salmon, as a seafood species, has been largely examined [21–34], followed by oysters [10,24,25,35–38], shrimps [24,25,39–42], pangasius [18,28,31,43], and tuna [9,28,44,45]. As such, all these studies are united by the adoption of product-specific attributes (Supplementary Materials Table S1) whereby consumers maximize their satisfaction utility and perceived product quality [46].

### *1.3. Purpose, Justification, and Significance*

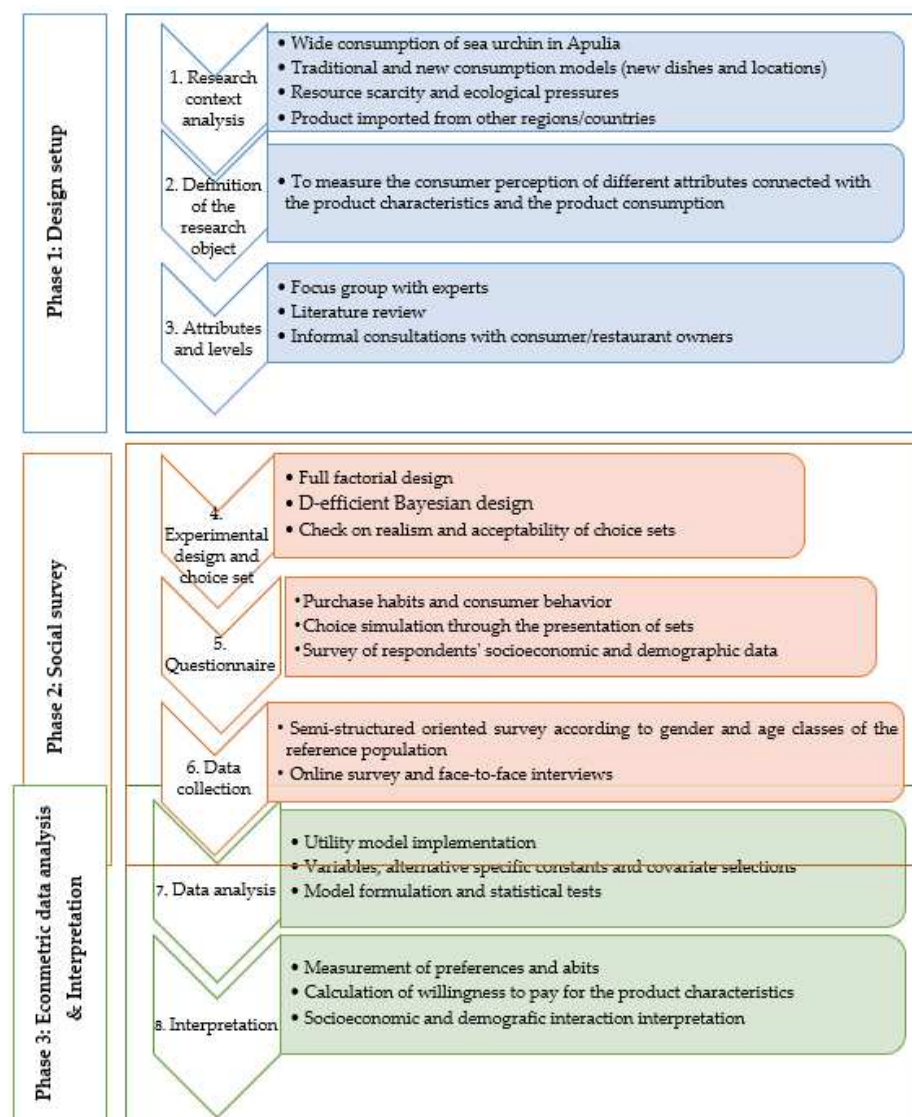
In this regard, within the project “TuGePIAl”, funded by the Apulia region (Appendix A), an economic study of sea urchin supply and demand was conducted to determine the main characteristics of its economic value chain, with particular attention to the analysis of the demand for fresh and processed marine products and the main sales channels, as well as the study of the supply, structure, and flows of the production chain in terms of volume and value. In this context, this research was carried out to elicit factors allowing to understand the behavior, preferences, and purchasing decisions of Italian consumers towards selected specific dishes based on seafood and to estimate their WTP for an edible local sea urchin, qualified as a niche product, caught from the Apulian Sea and sold in its markets. Precisely, this research addressed three interlinked research foci: (i) What are Apulian consumers’ behavior and propensity towards consuming sea urchin? (ii) What is their WTP for the presence of certification and the place of consumption of sea urchin? (iii) How do their socioeconomic characteristics influence their WTP? As such, this research contributes to the scientific literature in various dimensions. First, there is a dearth of studies that have applied a DCE to elicit sea urchin consumers’ behaviors and preferences as supported by the analogous experimental literature, described above (Section 1.2). Second, the Apulian seafood market has never been focused on consumer behavior, preferences, and WTP towards seafood and, particularly, sea urchin food. As such, referring to this region as a study area, we complement a previous study [47] conducted to propel Sardinian (an autonomous Italian region and the second-largest island in the Mediterranean Sea) consumers’ behavior and to elicit their WTP for sea urchin in varying dish patterns, including certification and place of consumption as particular attributes. In this framework, the study explored new insights into Italian regional differences in seafood preferences utility. Third, the current econometric valuation study is essential for the anticipation and setting up of market and innovation outreach strategies by seafood suppliers and restaurateurs that would meet Italian consumers’ expectations and, consequently, enhance their financial performances. Fourth, examining consumers preferences and perception has also public health implications in terms of increasing communication and information concerning origin labeling on seafood to impact

the healthy consumption of seafood species such sea urchin. For these purposes, we used a discrete choice experiment (DCE) approach by means of a multinomial logit model (MNL) and mixed logit model (MXL), and the following section addresses how this was designed.

## 2. Materials and Methods

### 2.1. Discrete Choice Experiment

DCE, a well-established method, is widely used to understand consumers' preferences and to estimate their WTP towards food product characteristics (i.e., attributes) such as food and/or seafood. Based on utility theory, we conducted the DCE in 3 phases which were divided in 8 steps (Figure 3), as follows: Phase 1—design set-up, which included the (i) research context analysis, (ii) definition of the research object, and (iii) selection of the attributes and the assignment of levels. Phase 2—survey, which included the (iv) experimental design and construction of choice sets, (v) realization of the questionnaire, and (vi) data collection. Phase 3—analysis and interpretation of the data, which included the (vii) data analysis using an econometric-based model and the (viii) interpretation of the preferences and the estimation of the WTP for the product characteristics.



**Figure 3.** Overview of the discrete choice experiment (DCE) approach. The diagram highlights the steps in each phase of the DCE that were considered in our study, in which steps 1 and 2 have already been described in Section 1.

## 2.2. Selection of Attributes and Assignment of Levels

We selected five attributes, inspired by Furesi et al. [47], as presented in Table 1. The selection of these attributes was justified by their importance in terms of traceability for Italian consumers' WTP. In fact, we believe that the certification of a product, as a trustworthy attribute [42] and regarded also by consumers as a food safety attribute, is decisive in marketing strategies that may help to improve the performance of the sea urchin market. With respect to the place of consumption, we also considered that the significance of the consumption circumstances could influence or affect consumers' WTP. Regarding the price, this attribute was considered here as a discrete variable [48], and its level was based on those applied above and below the current average retail selling price of the most popular Apulian seafood dishes.

**Table 1.** Attributes and levels used to elicit Italian sea urchin consumers' preferences in the survey.

| Attribute               | Level Number | Level                                                                     |
|-------------------------|--------------|---------------------------------------------------------------------------|
| Food type               | 2            | 1. Sea urchin<br>2. Seafood                                               |
| Certification of origin | 2            | 1. Yes<br>2. No                                                           |
| Place of consumption    | 2            | 1. Restaurant<br>2. Home                                                  |
| Dish type               | 2            | 1. Raw sea urchin as starter<br>2. Sea urchin with pasta as a main course |
| Price                   | 4            | 1. EUR 10<br>2. EUR 15<br>3. EUR 20<br>4. EUR 25                          |

## 2.3. Experimental Design and Choice Set

An important step in a DCE concerns the definition of the experimental design. In this regard, given the excessive number of alternatives ( $2^4 \times 4$ ) resulting from the combination of the selected attributes and their respective levels (Table 1), we carried out a D-efficient Bayesian design, which allows for the maximization of the statistical efficiency by minimizing the D-error [49,50], using Equation (1). Starting from 2016, according to the possible alternative combinations, in addition to the “no choice” option, we generated 16 reasonable profiles arranged in one block [15] of 8 choice sets. The latter included 2 alternatives (Options A and B) and a “no-choice” (Option C), as presented in Table 2. The first four choice sets contained the main course alternatives. The other four included the starter alternatives. In each choice set, a sea urchin dish type was compared with a seafood dish type. We also supported each choice set using visual symbols [51] to facilitate the selection and to avoid consumers' confusion. As such, the respondent selected the option that maximized their total utility regarding sea urchin consumption under a budget limitation [26,52].

$$N = \frac{J^n (J^n - 1)}{2} \quad (1)$$

where  $J$  is the number of levels, and  $n$  is the number of attributes.

**Table 2.** Example of a set choice used in the survey.

| Choice Set in Which Raw Sea Urchin is Served as the Main Course |                                                                                                                                                                                                                                                                                                                                                                    | Choice Set in Which Raw Sea Urchin is Served as the Starter |                                                                                                                                                                                                                                                                                                                                                            |
|-----------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| A                                                               |   <p>No certification of origin</p>  <p>At home</p> <p>Main course with pasta and sea urchin</p> <p>10 €</p>    | A                                                           |   <p>Certification of origin</p>  <p>At home</p> <p>Starter with raw sea urchin</p> <p>25 €</p>    |
| B                                                               |   <p>Certification of origin</p>  <p>At restaurant</p> <p>Main course with pasta and seafood</p> <p>15 €</p> | B                                                           |   <p>No certification of origin</p>  <p>At home</p> <p>Starter with raw seafood</p> <p>20 €</p> |
| C                                                               | <p><b>X</b></p> <p><b>No choice</b></p>                                                                                                                                                                                                                                                                                                                            | C                                                           | <p><b>X</b></p> <p><b>No choice</b></p>                                                                                                                                                                                                                                                                                                                    |

I will opt for:

(Select one option using the symbol ☒)

Option A: \_\_\_\_; Option B: \_\_\_\_; Option C: \_\_\_\_.

I will opt for:

(Select one option using the symbol ☒)

Option A: \_\_\_\_; Option B: \_\_\_\_; Option C: \_\_\_\_.

#### 2.4. Questionnaire Design

We designed a social choice questionnaire [48] in 3 parts (Appendix A). The first part investigated the behavior and propensity to buy and to consume sea urchin, along with 7 general categorical questions, using a Likert scale tool [53], which provides more information than binary answers, such as: “Have you ever bought sea urchin for domestic consumptions or during aperitifs/lunches/diners outside your home?” (Q1); “Where do you usually acquire sea urchin?” (Q2); “Where do you habitually consume sea urchin?” (Q3); “When purchasing sea urchin, how much attention (high, medium, or low) do you pay to the following characteristics: price, appearance, in terms of color and size, storage method, reliability of the seller, place of sale, presence of a label of origin and quality, information about the fishing area?” (Q4); “According to your personal experience, how much (high, medium, or low) of the following characteristics affect the price of sea urchin: appearance, in terms of color and size, storage method, reliability of the seller, place of sale, presence of a label of origin and quality, information about the fishing area?” (Q5); “Which of the following sentences identifies better your behavior in relation to the purchase: I am willing to buy a larger quantity if the price is low, I am willing to pay a higher price for a safe and certified product, I prefer the quality and price ratio without considering

the origin of the product, Other?” (Q6); “Which sentence identifies better your behavior regarding the consumption of sea urchin: I prefer to consume sea urchin at home, in my comfort zone; I prefer to consume sea urchin outside home, in a convivial context; I prefer to consume sea urchin in a formal environment?”. The second part of the questionnaire presented 8 purchase simulations (i.e., set choice) in which each respondent had to select between 2 options (A and B) among each set choice that differed in the type of dish, certified origin, place of consumption, and price. The set choice also included a no-purchase option (C). Table 2 illustrates an example of a set choice used in this study, displayed using images with a description in the caption [54]. In the third part of the questionnaire, we collected socioeconomic data on the respondents in relation to gender, age, residence, civil status, and family composition, level of education, work position, work sector, and annual household income. Our intention was to understand the potential significance of this kind of information on consumption behavior and preferences as well as on WTP levels. As such, we attentively pre-examined this questionnaire survey through a pilot social survey of 22 respondents.

### 2.5. Sampling of Respondents and Data Collection

We collected data from November 2021 till September 2022 through online and face-to-face surveys in several locations of the Apulia region, involving 453 valid seafood respondents, considering both the Apulian population’s age and gender distribution (Table 3), in which the sample presented a similar structure as the Apulian population. As such, we based our sampling on the Istat database [55], and we obtained an appropriate sample size of at least 385 Apulian respondents by using the calculator [56] within a margin of error of 5%, a confidence level of 95%, and a total population size of 3,295,839 inhabitants, in which age classes younger or equal to 18 years were not included in the formula of the sample size, as follows:

$$n = N \times X / (X + N - 1) \quad (2)$$

where  $X = Z_{\alpha/2}^2 \times p \times (1 - p) / (\text{MOE})^2$ ;  $Z_{\alpha/2}$  is the critical value of the normal distribution at  $\alpha/2$  (for a confidence level of 95%,  $\alpha$  is 0.05, and the critical value is 1.96); MOE is the margin of error;  $p$  is the sample proportion; and  $N$  is the population size.

**Table 3.** Sampling of the respondents taking into consideration the age, gender, and household revenue of the population in the Apulia region.

|                                  |               | Apulia Region | Sample |
|----------------------------------|---------------|---------------|--------|
| Age class                        | 19–30         | 17.00%        | 13.00% |
|                                  | 31–50         | 31.00%        | 36.00% |
|                                  | Over 50       | 52.00%        | 50.00% |
| Gender                           | Male          | 49.00%        | 51.00% |
|                                  | Female        | 51.00%        | 49.00% |
| Annual household income<br>(EUR) | <20,000       |               | 29.00% |
|                                  | 20,000–40,000 | 31,156        | 58.00% |
|                                  | 40,000–60,000 | (average)     | 12.00% |
|                                  | >60,000       |               | 1.00%  |

Source: Istat, 2021 [55].

### 2.6. Econometric Model: Data Analysis and Interpretation

We based our econometric data analysis and interpretation, using NLogit version 5.0, on random utility models [46] in which the respondent based their purchase decision by choosing the option (A, B, or C, as mentioned above) that maximized their satisfaction utility and perceived seafood species quality. In other words, considering respondent  $i$ , who chooses the alternative that can guarantee the greatest utility among the  $J$  possi-

ble alternatives at a given occasion of choice  $T$ , the utility function is thus given by the following equation [57]:

$$U_{ijt} = V_{ijt} + e_{ijt}, \quad i = 1, \dots, I; \quad j = 1, \dots, J; \quad t = 1, \dots, T \quad (3)$$

where  $V_{ijt}$  is the deterministic component, and  $e_{ijt}$  is the random component, independently and identically distributed (IID).

Considering the individual characteristics to stress the heterogeneity of the preferences and assuming a linear utility function in the parameters for the deterministic component, Expression (3) can be reformulated as:

$$U_{ijt} = \beta'_i x_{ijt} + \varepsilon_{ijt}, \quad i = 1, \dots, I; \quad j = 1, \dots, J; \quad t = 1, \dots, T \quad (4)$$

where  $\beta_i$  is a vector of  $K \times 1$  parameters to be estimated and inherent in utility, corresponding to  $K$  choice characteristics;  $x_{ijt}$  is the  $K \times 1$  vector of the characteristics of choice concerning alternative  $j$  at the choice occasion  $t$  made by individual  $i$ .

In this regard, it should be noted that respondents may exhibit similar attitudes in their choices across choice sets, leading to the phenomenon of correlation and, thus, violation of the IID assumption. Expression (4), on the other hand, involves the introduction of a vector of  $\beta_i$  parameters that are specific to the respondents and following a distribution  $g(\beta|\theta)$ , whose vector  $\theta$  indicates the mean and variance. This specification, allowing for the above assumption to be relaxed, refers to the random parameter logit model (RPLM), which allows for the capture of the heterogeneity related to factors not observed but common to groups of respondents and able to influence their behavior, hence, decision making. The conditional probability on parameters  $\beta_i$  that an individual  $i$  will choose a sequence of choices  $s_i = \{s_{i1}, s_{i2}, \dots, s_{iT}\}$ , given profiles  $x_i = \{x_{i1}, x_{i2}, \dots, x_{iT}\}$ , is given by:

$$P(s_i|x_i, \beta) = \prod_{t=1}^T \left[ \frac{\exp(\beta'_i x_{is_{it}t})}{\sum_{j=1}^J \exp(\beta'_i x_{ijt})} \right] \quad (5)$$

Integrating (5) with respect to the distribution of  $\beta$  yields the unconditional probability, so that:

$$P(s_i|x_i, \theta) = \int_{\beta} P(s_i|x_i, \beta) g(\beta|\theta) d\beta \quad (6)$$

However, (6) does not present a closed-form solution, so for the estimation of the model, simulated maximum likelihood methods are used [57,58]. Since Halton extractions are an efficient alternative to random extractions, in this study, the method was used of Halton at 200 extractions. In addition, a normal distribution was used for the functional form of the parameter density functions [59]. As regards the calculation of the WTP, that is, the contribution that respondents are willing to pay for each proposed product characteristic, the following expression was used:

$$WTP_A = -\frac{\beta_A}{\beta_P} \quad (7)$$

where  $WTP_A$  is the willingness to pay for attribute  $A$ ;  $\beta_A$  and  $\beta_P$  are the estimated coefficients related to each attribute and price, respectively.

### 3. Results

#### 3.1. Basic Descriptive Statistics

This section includes basic statistical results from the Parts 1 and 3 of the questionnaire, dealing with consumers' general attitudes towards the behavior and propensity to consume sea urchin and their sociodemographic and economic characteristics in the studied area. Fish shops were the most popular places of purchase for sea urchin (42%),

followed by restaurants (21%) and fishermen (15%). The majority of the respondents that purchased at fish shops consumed this seafood species at home (77.10%), while 18.70% of them consumed it in restaurants. Home was the place of consumption preferred by the majority of people purchasing at fishermen (49%). People that consumed urchins directly from the sea, purchased it from fishermen or caught sea urchin by themselves as hobby fishermen (Table 4).

**Table 4.** Purchase sites by consumption place of sea urchin (in % of respondents), excluding restaurants (conventional restaurant and restaurant-fish, representing together more than 30%).

| Place of Purchase        | Place of Consumption (in %) |        |            |                      |       |                |
|--------------------------|-----------------------------|--------|------------|----------------------|-------|----------------|
|                          | Total                       | Home   | Restaurant | Fish Shop Restaurant | Sea   | No Consumption |
| Online                   | 0.00                        | 0.00   | 0.00       | 0.00                 | 0.00  | 0.00           |
| Peddler                  | 4.00                        | 100.00 | 0.00       | 0.00                 | 0.00  | 0.00           |
| Shopping mall            | 1.00                        | 100.00 | 0.00       | 0.00                 | 0.00  | 0.00           |
| Kiosk                    | 1.00                        | 0.00   | 0.00       | 100.00               | 0.00  | 0.00           |
| Fisherman (direct sales) | 15.00                       | 49.00  | 4.00       | 18.00                | 29.00 | 0.00           |
| Fish shop                | 42.00                       | 77.00  | 19.00      | 4.00                 | 0.00  | 0.00           |
| No purchase              | 5.00                        | 0.00   | 17.00      | 0.00                 | 44.00 | 39.00          |

Although 74% of the respondents in this social survey accorded a high level of attention towards the reliability of the seller, which means that their purchase decision was really influenced by this product feature in the studied area, followed by the relative importance of the aspect, mode of conservation, and purchase site of sea urchin (Table 5). With regard to their self-level experience with the level of influence of sea urchin features on its purchase price, very few respondents (2%) were convinced that the aspect of the product influenced its purchase price, but 52% of them confirmed the high level of influence of the origin and quality label (Table 6).

**Table 5.** Self-level attention on the characteristics of sea urchin among Apulian consumers (in % of respondents).

| Sea Urchin Feature                   | Level of Attention (in %) |       |        |       |        |       |
|--------------------------------------|---------------------------|-------|--------|-------|--------|-------|
|                                      | Low                       |       | Medium |       | High   |       |
|                                      | Number                    | %     | Number | %     | Number | %     |
| Price                                | 60                        | 13.00 | 242    | 53.00 | 151    | 33.00 |
| Aspect                               | 13                        | 3.00  | 146    | 32.00 | 294    | 65.00 |
| Mode of conservation                 | 43                        | 10.00 | 110    | 24.00 | 300    | 66.00 |
| Reliability of the seller            | 20                        | 4.00  | 100    | 22.00 | 333    | 74.00 |
| Purchase site                        | 28                        | 6.00  | 152    | 34.00 | 273    | 60.00 |
| Presence of origin and quality label | 221                       | 49.00 | 137    | 30.00 | 95     | 21.00 |
| Information on the fishing zone      | 167                       | 37.00 | 140    | 31.00 | 146    | 32.00 |

In general, sea urchin obtained the highest willingness to pay a price premium if the product was safe and certified (approximately 57%), followed in succession by its other features, such as an adequate quality/price ratio, without caring about the origin (32.3%), and price (approximately 11% of the respondents were willing to buy a larger amount if the price was low), as shown in Table 7. Furthermore, most Apulia consumers (57.17%) preferred to consume sea urchin outside, in a convivial context, while few of them (approximately 5%) preferred to consume this marine species in a formal context, as shown in Table 8.

**Table 6.** Self-level experience with the level of influence of sea urchin features on its purchase price (in % of respondents).

| Sea Urchin Feature                   | Level of Influence (in %) |       |        |       |        |       |
|--------------------------------------|---------------------------|-------|--------|-------|--------|-------|
|                                      | Low                       |       | Medium |       | High   |       |
|                                      | Number                    | %     | Number | %     | Number | %     |
| Aspect                               | 9                         | 2.00  | 116    | 26.00 | 328    | 72.00 |
| Mode of conservation                 | 63                        | 14.00 | 165    | 36.00 | 225    | 50.00 |
| Reliability of the seller            | 94                        | 21.00 | 115    | 25.00 | 244    | 54.00 |
| Purchase site                        | 56                        | 12.00 | 97     | 22.00 | 300    | 66.00 |
| Presence of origin and quality label | 118                       | 26.00 | 98     | 22.00 | 237    | 52.00 |
| Information on the fishing zone      | 108                       | 24.00 | 144    | 32.00 | 201    | 44.00 |

**Table 7.** Apulian consumers' behavior related to sea urchin purchasing.

|                                                                                          | Number | %      |
|------------------------------------------------------------------------------------------|--------|--------|
| I am willing to buy a larger amount if the price is low                                  | 49     | 11.00  |
| I am willing to pay a price premium if the product is safe and certified                 | 258    | 57.00  |
| I prefer an adequate quality/price ratio, without caring about the origin of the product | 146    | 32.00  |
| No answer                                                                                | 0      | 0.00   |
| Total                                                                                    | 453    | 100.00 |

**Table 8.** Apulia consumers' behavior related to sea urchin consumption.

|                                                                | Number | %      |
|----------------------------------------------------------------|--------|--------|
| I prefer to consume sea urchin at home                         | 144    | 32.00  |
| I prefer to consume sea urchin outside, in a convivial context | 259    | 57.00  |
| I prefer to consume sea urchin in a formal context             | 20     | 4.00   |
| Other (I prefer to consume sea urchin at the seaside)          | 21     | 5.00   |
| No answer                                                      | 9      | 2.00   |
| Total                                                          | 453    | 100.00 |

Regarding the socioeconomic profiles (Table 9), on average, the respondents were middle-aged (48.51 years old), mainly residents of the Apulia region (94%), and equally divided between genders, since 49.2% were female, but they were widely differentiated with respect to family size (one member: 11.7%, two members: 25.6%, three members: 30.5%, four members: 25.6%, and more than four members: 6.6%). In terms of education, three major classes were observed: one with a high school diploma (approximately 41.3%), one with a bachelor's degree (32.5%), and one with a post-bachelor's degree (25.6%). Most of the respondents were employed (35.5%), and the total annual household revenue was distributed as follows: 28.70% (under EUR 20,000), 58.06% (EUR 20,000–40,000), 11.92% (EUR 40,000–60,000), and 1.32% (over EUR 60,000).

### 3.2. Econometric Results

#### 3.2.1. Sea Urchin Consumers' Perception

The multinomial logit model (MNL) estimates are reported in Table 10, in which all coefficients of the concerned attributes presented positive signs, except for price, as envisaged, and were highly significant at the notable level of 1%. On the contrary, the ASC No choice coefficient (i.e., no buy) was equal to  $-0.14$  and not significant. This result indicates that the respondents strongly preferred to consume dishes based on sea urchin presented as the main dish or starter. Further, the certificate of origin coefficient ("certification"), as anticipated, was positive and highly significant ( $p = 0$ ). This finding denotes that "certification" provided consumers with high assurance or trust regarding, at least, the

quality of the seafood species. In addition, the sign for the attribute regarding the place of consumption (“restaurant”) was positive and highly significant ( $p = 0$ ), indicating that this attribute provided Apulian consumers with higher pleasurable service in restaurants in which sea urchin is served as the principal dish or seasoned/savored with pasta or pizza.

**Table 9.** Socioeconomic characteristics of the respondents.

| Social and Demographic Variable (Unit) | Category                | Median | Mean  |
|----------------------------------------|-------------------------|--------|-------|
| Age (year)                             | -                       | 50     | 48.51 |
|                                        |                         | Number | %     |
| Gender                                 | Female                  | 223    | 49.00 |
|                                        | Male                    | 230    | 51.00 |
| Residence                              | Inside Apulia region    | 426    | 94.00 |
|                                        | Outside Apulia region   | 27     | 6.00  |
| Household composition (number)         | 1                       | 53     | 12.00 |
|                                        | 2                       | 116    | 26.00 |
|                                        | 3                       | 138    | 30.00 |
|                                        | 4                       | 116    | 26.00 |
|                                        | 5                       | 30     | 7.00  |
| Education level                        | Illiterate              | 0      | 0.00  |
|                                        | Elementary              | 0      | 0.00  |
|                                        | Lower secondary school  | 3      | 0.70  |
|                                        | Higher secondary school | 187    | 41.00 |
|                                        | Bachelor                | 147    | 32.00 |
|                                        | Master and PhD          | 116    | 26.00 |
| Work position                          | Student                 | 7      | 1.00  |
|                                        | Unemployed              | 21     | 5.00  |
|                                        | Employed                | 161    | 35.00 |
|                                        | Entrepreneur            | 59     | 13.00 |
|                                        | Freelance               | 107    | 24.00 |
|                                        | Operator                | 7      | 1.00  |
|                                        | Manager                 | 23     | 5.00  |
|                                        | Retired                 | 31     | 7.00  |
|                                        | Other                   | 37     | 8.00  |
| Annual household income (EUR)          | <20,000                 | 130    | 29.00 |
|                                        | 20,000–40,000           | 263    | 58.00 |
|                                        | 40,000–60,000           | 54     | 12.00 |
|                                        | >60,000                 | 6      | 1.00  |

**Table 10.** Multinomial logit model (MNL) results.

| MNL                     | Coefficient  | Standard Error | z  > Z * | Confidence Interval |          |
|-------------------------|--------------|----------------|----------|---------------------|----------|
| Price                   | −0.05442 *** | 0.00488        | 0        | −0.06398            | −0.04485 |
| Certification           | 1.49969 ***  | 0.05833        | 0        | 1.38537             | 1.61402  |
| Place: Restaurant       | 0.5442 ***   | 0.05656        | 0        | 0.19373             | 0.41543  |
| ASC Sea urchin          | 0.0756       | 0.04718        | 0.1091   | −0.01689            | 0.16808  |
| ASC Type of dish        | −0.00331     | 0.7800         | −0.04    | −0.15619            | 0.14957  |
| ASC Opt-out (no choice) | −0.14356     | 0.11554        | 0.214    | −0.37               | 0.08289  |

Note: \*\*\*, \* ==> Significance at 1%, 10% level.

With respect to the RPL model, the log likelihood function and pseudo  $R^2$  fulfilled better values compared to the MNL model (Table 11). The RPL estimates (Table 12) show that all the concerned attributes were coherent with the MNL model, indicating also a high statistical significance at the 1% level and rejecting the hypothesis of homogeneous consumer preferences for sea urchin preparation and consumption. In other words, this

result assumes variation in the utility coefficients across the respondents. The ASC No choice coefficient (i.e., no buy) was positive but not significant, indicating that consumers would gain utility from Option A or Option B over Option C. Moreover, the coefficient “certification” attribute was positive and highly significant as well as for the place of consumption “restaurant”, suggesting that consumers obtained high utility from a certified sea urchin product consumed in restaurants. Moreover, the interaction between ASC Opt-out, propensity variables, and the socioeconomic characteristics of the respondents was elaborated to explain this consumers’ heterogeneity in preferences for sea urchin. The findings reveal that the correspondent coefficients with negative and significant levels (Table 12) imply that respondents attributed a high degree of importance when making choices between options. In other words, the consumption utility of sea urchin was related to a greater influence by place of purchase “street vendor and mall”, place of consumption “sea”, “technique of conservation”, “appearance”, “quality label”, “fishing zone”, “more quantity for low price”, “male buyer”, and “medium and high incomes”. On the contrary, the coefficients with positive signs indicate that the correspondent covariates influenced Option C (i.e., No buy).

**Table 11.** Multinomial logit (MNL) model and random parameter logit (RPL) model parameters.

|                                | MNL      | RPL      |
|--------------------------------|----------|----------|
| Log likelihood function        | −3488.10 | −3165.88 |
| McFadden pseudo R <sup>2</sup> | 0.12     | 0.20     |
| AIC/N                          | 1.93     | 1.76     |
| Number of respondents          | 453      | 453      |
| Number of observations         | 3624     | 3624     |
| Number of Halton draws         | -        | 200      |

**Table 12.** Random parameter logit (RPL) results.

| RPL                                         | Coefficient  | Standard Error | z  > Z * | Confidence Interval |          |
|---------------------------------------------|--------------|----------------|----------|---------------------|----------|
| Fixed parameter                             |              |                |          |                     |          |
| Price                                       | −0.06261 *** | 0.00513        | 0        | −0.07267            | −0.05256 |
| Certification                               | 1.64471 ***  | 0.06355        | 0        | 1.52017             | 1.76926  |
| Place of consumption: Restaurant            | 0.27141 ***  | 0.05948        | 0        | 0.15483             | 0.38799  |
| ASC Sea urchin                              | 0.06149      | 0.04811        | 0.2012   | −0.0328             | 0.15579  |
| ASC Dish type                               | −0.00494     | 0.08647        | −0.06    | −0.17441            | 0.16453  |
| Random parameter                            |              |                |          |                     |          |
| ASC Opt-out                                 | −3.14714 *** | 0.63295        | 0        | −4.3877             | −1.90657 |
| Heterogeneity in mean<br>Parameter variable |              |                |          |                     |          |
| Frequency middle                            | −0.00777     | 0.181          | 0.9658   | −0.36251            | 0.34698  |
| Frequency high                              | 0.15326      | 0.25238        | 0.5437   | −0.34141            | 0.64792  |
| Place of purchase: Street vendor            | −3.08949 *** | 0.80548        | 0.0001   | −4.6682             | −1.51078 |
| Place of purchase: Mall                     | −0.23139     | 0.93367        | 0.8043   | −2.06134            | 1.59857  |
| Place of purchase: Kiosk                    | 2.0313 ***   | 0.50354        | 0.0001   | 1.04437             | 3.01822  |
| Place of purchase: Fish shop                | 0.63973 ***  | 0.19944        | 0.0013   | 0.24883             | 1.03063  |
| Place of consumption: sea                   | −3.03898 *** | 0.4782         | 0        | −3.97623            | −2.10172 |
| Place of consumption: Home                  | −0.19562     | 0.37213        | 0.5991   | −0.92498            | 0.53374  |
| Place of consumption: Restaurant            | −0.17706     | 0.37275        | 0.6348   | −0.90764            | 0.55352  |
| Place of consumption: Restaurant-fish shop  | −0.18386     | 0.41752        | 0.6597   | −1.00217            | 0.63446  |

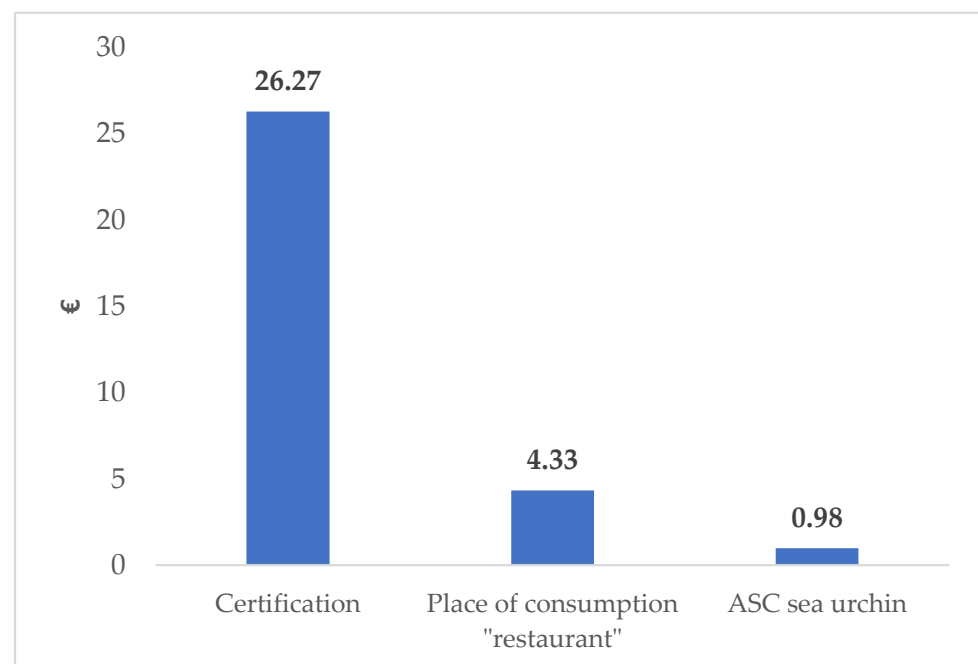
Table 12. Cont.

| RPL                                        | Coefficient  | Standard Error | z  > Z * | Confidence Interval |          |
|--------------------------------------------|--------------|----------------|----------|---------------------|----------|
| Pay attention to price                     | 1.04603 ***  | 0.15352        | 0        | 0.74513             | 1.34693  |
| Pay attention: Appearance                  | 0.75561 ***  | 0.14991        | 0        | 0.46178             | 1.04943  |
| Pay attention: Way of conservation         | −0.43484 *** | 0.16871        | 0.01     | −0.7655             | −0.10418 |
| Pay attention: Seller reliability          | 0.33725 **   | 0.17028        | 0.0476   | 0.00352             | 0.67099  |
| Pay attention: Place of purchase           | −0.01148     | 0.15103        | 0.9394   | −0.30749            | 0.28453  |
| Pay attention: Quality label               | −0.28709     | 0.22558        | 0.2031   | −0.72921            | 0.15503  |
| Influence on price: Appearance             | −0.42951 **  | 0.18299        | 0.0189   | −0.78816            | −0.07085 |
| Influence on price: Way of conservation    | 0.20535      | 0.15415        | 0.1828   | −0.09678            | 0.50748  |
| Influence on price: Seller reliability     | 0.17404      | 0.15222        | 0.2529   | −0.1243             | 0.47239  |
| Influence on price: Place of purchase      | 0.7173 ***   | 0.17799        | 0.0001   | 0.36844             | 1.06616  |
| Influence on price: Quality label          | −0.89667 *** | 0.1366         | 0        | −1.1644             | −0.62894 |
| Influence on price: Fishing zone           | −0.4305 ***  | 0.15728        | 0.0062   | −0.73876            | −0.12225 |
| Behavior: More quantity if price is low    | −0.82739 *** | 0.2442         | 0.0007   | −1.30601            | −0.34876 |
| Behavior: Pay more for a certified product | 0.50843 ***  | 0.18228        | 0.0053   | 0.15117             | 0.86569  |
| Male buyer                                 | −0.90118 *** | 0.13998        | 0        | −1.17554            | −0.62682 |
| Age                                        | 0.04389 ***  | 0.00628        | 0        | 0.03158             | 0.0562   |
| Years of study                             | 0.05404 ***  | 0.01985        | 0.0065   | 0.01513             | 0.09294  |
| Income: Medium                             | −0.31998 *   | 0.16895        | 0.0582   | −0.65112            | 0.01116  |
| Income: High                               | −0.81786 *** | 0.22237        | 0.0002   | −1.25371            | −0.38202 |
| Distribution of RPs                        |              | SD             |          |                     |          |
| No ASC Opt-out                             | 0.5327 ***   | 0.07891        | 0        | 0.37804             | 0.68736  |

Note: \*\*\*, \*\*, \* ==> Significance at 1%, 5%, 10% level.

### 3.2.2. Sea Urchin Consumers' Willingness to Pay

The distribution of WTP for the selected attributed are presented in Figure 4, in which the highest WTP is determined by the “Certification” attribute (average € 26.27/dish), followed by the place of consumption “Restaurant” (average €4.33/dish), and ASC sea urchin (average €0.98/dish). As such, Apulian consumers are willing to pay € 10.53/dish on overall average for sea urchin consumption.



**Figure 4.** Apulian consumers' willingness to pay for the consumption of sea urchin. ASC refers to alternative specific constant, which here represents the “none” option in each choice set.

According to the random parameter logit model results, the purchase behavior of the respondents was influenced by some of the covariates included in the model. The characteristics of the respondents that had significant reflection on the willingness to pay were those contributing to the heterogeneity in the mean variation. The covariates that negatively affected the WTP were those with a negative sign, as shown by results concerning people who purchase from street vendors, who consume directly from the sea, and who pay attention to the product's conservation. Moreover, the negative variation of the WTP was also constituted by those who think that price is influenced by the quality label and by the fishing zone. The same can be said for male buyer and households of medium- and high-income levels. The respondents' characteristics with a positive reflection on the WTP were those that had a positive sign related to the interaction with the opt-out parameter, such as those who purchase from kiosks and fish shops and who pay attention to price, product appearance, and seller reliability. Moreover, a positive WTP effect could be observed for the respondents who thought that the place of purchase influences the price level and who are willing to pay more for a certified product.

## 4. Discussion

### 4.1. Interpretation and Comparison

The obtained WTP was relatively high (on average, EUR 27.3) for certification features, suggesting consumers' perception and interest in greater and clearer labeling or information regarding the origin and source of the seafood product they consume. As such, the origin of the product appears here to be a determinant criterion for Italian consumers. This certainly reflects their concern regarding the sustainable conditions of harvesting and processing, as well as antifraud issues related to seafood products. In other words, information concerning this feature seems to prevail in the dish pattern presentation and/or the situational factors consumption attributes [60]. This result is consistent with Nguyen et al. [44], who found that improving communication on seafood species, preparation methods, and product forms prior to cooking was barely significant with respect to product origin, production methods, and sustainability certification. Moreover, our results are consistent with several other previous studies that estimated consumers' WTP for sustainable seafood products through the perception of specific attributes [9,21,31,61–65], particularly the study by Bastounis et al. [66], in which consumers were willing to pay more for ecosustainable products and where ecolabels were a promising strategy to encourage this type of purchase.

Moreover, Carlucci et al. [10] found that, in Italy, consumers are willing to pay a significant price premium for certification labels but without preferring any kind of certification. In addition, our findings are in line with Risius et al. [67], who found that there was a clear preference for domestic seafood products, perceived as superior in quality, safety, and freshness compared to imported fish. Furthermore, Risius et al. [67], aiming to conduct a segmentation of fish consumers based on preferences for different product attributes to identify target groups for fish from sustainable aquaculture and for different countries of origin, identified five target groups, the most relevant (39%) of which gave the highest importance to the country of origin, while another (20%) gave priority to the country of origin over all other attributes. In addition, Nguyen et al. [44] showed that consumers perceive domestic seafood as safer and have a high willingness to pay for seafood of domestic origin. Chen et al. [36] analyzed Hawaiian chefs' preferences for the attributes of locally raised oysters to calculate the marginal willingness to pay for this seafood. The study in question, therefore, addressed the attributes related to price, breeding site, freshness, and stability of supply. The results showed that the respondents favored fresh (and nonfrozen) oysters, locally raised (not imported from abroad) and supplied on the basis of availability (not according to a pre-established schedule). In addition, chefs were willing to pay USD 5.25 more for a dozen locally raised oysters; therefore, it might be interesting to delve into this research topic for other seafood and a larger sample of respondents (of 27) and from other countries. On the contrary, our results are not in line with Cantillo et al. [65], who analyzed and identified the main determinants of the frequency of fishery and aquaculture

products (FAPs) for domestic consumption. Their results indicated that the main reasons for consuming FAPs were related to their healthiness, taste, and relatively low price. However, they also highlighted that the reason why consumers should consume them less frequently was related to a lack of understanding of the information that accompanies these products.

In relation to the place of consumption, recently, Nguyen et al. [44] published two different studies that revolve around the issue of the information presented on restaurant menus, the first of which delves into the preferences of American consumers in reference to obtaining information on seafood appetizers served in casual (midrange) and fine (upscale) restaurants. According to this research, the demand for information on the fish served varied according to the attribute submitted to consumers; however, more than 80% of respondents said they were satisfied with the species identification, cooking method, and price attributes.

#### *4.2. Findings and Implications*

The obtained results induce here public and private implications. In fact, examining consumers' preferences according to some purchase attributes may urge cohesion and dialogue between fisherman practices and consumer behavior for a better protection of the biodiversity of marine ecosystems and, above all, species of sea urchin currently at risk of extinction in the study area. Furthermore, within the broader vision of the Europe 2020 strategy for smart, sustainable, and inclusive growth, this research implies innovative scientific and evaluative economic results/contributions in line with the EU's priority regarding the promotion of environmentally sustainable resource-efficient fisheries that are innovative, competitive, and knowledge based. Overfishing of natural stocks of seafood such sea urchin to satisfy the growth of its demand, as well as the marine habitat damage, may generate a regional crisis in the production of this kind of sea product. To avoid this potential crisis, we need sustainable and innovative systems for the management of sea urchin production and consumption that will comprehensively attenuate the impact on natural sea resources. Given this, with the examination of consumption and potentially changing habits, it is possible to condition the market and reverse the course by supporting sustainable fishing and preserving the sea in the study area. With respect to the private implications, in addition to increasing consumers' awareness and enhancing their nutrition–health conditions, this study may promote the creation of a local (Apulia) sea urchin brand through the adoption of a market policy and a particular regulation related to the certification of origin, recognizing that Apulian consumers are willing to pay a price premium for a safe and certified marine heritage. While respecting the complex balance of the marine ecosystems, the creation of such a specific geographic brand may allow for the achievement of good business performances and potentially increase the levels of competitiveness and profitability of fish stakeholders.

#### *4.3. Limitations and Future Research Directions*

Our study involved representative respondents considered as the “general public”, which may be considered relatively less valuable for some fish stakeholders such as seafood restaurateurs. Since this study revealed a respondent utility of consumption of sea urchin at restaurants, we suggest an extension on examining Italian consumer needs regarding sea urchin served at midscale and upscale restaurants [65] in Apulia and other southern regions of the country through a face-to-face field social survey and including another seafood species [44]. The use of an online survey was also a limitation of this study, since this kind of data collection may mainly exclude elderly persons [68,69]. As such, we may allow for extending the analysis of the consumer differentiation between communities and different age classes. Further, the sustainability of seafood production and consumption has emerged. Therefore, the list of the attributes may be extended in a further study to cover the impact of the environmental conditions of fishing and processing, nutritional/health claims, and safety information issues [70] on Apulia sea urchin consumers' behavior and their WTP. Moreover, to avoid extreme values of the WTP, a payment card question could

be suggested to respondents asking them: “if the price of a seafood dish (such as sea urchin) in a restaurant is EUR ‘value X’, how much more are you willing to pay as a % of this price for the selected attributes [44]”.

## 5. Conclusions

The analysis conducted revealed, among others, a particularly significant element with respect to the effects on the market of the fish product in question. The consumer was willing to pay a price premium towards the guarantee of purchasing a certified product, in terms of the quality and origin, and that was traceable in relation to all of the links in its value chain, organoleptically intact, and preferably of local origin. Meanwhile, this seafood attribute was linked to the contents of ecological–environmental sustainability on which the agrifood and structural and rural development policies of the European Union, as well as those of the United Nations, have been based since the end of the 1980s and which have led to the adoption of a Code of Conduct for Responsible Fishing [71]. Fishing, as well as aquaculture, represents crucial productive dimensions of socioeconomic systems, with a fundamental value in terms of ecological–environmental resilience. However, overfishing of certain species of sea urchin, as well as uncontrolled harvesting by unauthorized fishermen, has led to the application of specific management policies (i.e., catch quotas, rotational fishing, and aquaculture) to allow for the restoration of stocks and/or mitigation of the impact on natural populations. From this perspective, Apulia, with its 830 km of coastline along the Adriatic and, in part, along the Ionian Sea, can certainly express a significant determination in favor of the enhancement of small coastal communities and their socioproductive commitment within this value chain. Furthermore, classified as a problematic region of southern Europe, Apulia can certainly seize opportunities to activate structural development paths that hoard productive specificities, such as that, for example, of the *Paracentrotus lividus*, launching paths of cultural enhancement [72]. From this perspective, the results provide some suggestions concerning the direction in which to drive sea urchin enhancement policies, based on consumer preferences. In this sense—according to the high estimated value of the specific attribute—the potential positive role that the certification of regional origin of the product can assume in the added value creation is evident. More generally, the certification of origin or that certifying compliance with good catching and/or traceability practices along the supply chain (i.e., “from the sea to the table”) could represent, even more than the place of consumption, the main leverage to enhance such an important resource that, however, is at risk of overexploitation. Obviously, these results need to be corroborated by other studies and empirical evidence, if anything, by also evaluating any other attributes referable to sea urchins and not contemplated in this study or in other reference markets other than the Apulian one.

**Supplementary Materials:** The following supporting information can be download at: <https://www.mdpi.com/article/10.3390/foods12020418/s1>, Table S1: Most attributes used by scientists to elicit consumers’ preferences of sea food products.

**Author Contributions:** Conceptualization, M.F. and A.P.; methodology, M.F., A.P. and F.B.; software, M.F. and A.P.; validation, V.F.; formal analysis, M.F. and F.B.; investigation, A.P. and A.A.C.; resources, F.B.; data curation, V.F.; writing—original draft preparation, M.F., A.P. and F.B.; writing—review and editing, M.F., A.P. and R.B.; visualization, M.F. and A.P.; supervision, F.M. and P.P.; project administration, V.F.; funding acquisition, F.B. and P.P. All authors have read and agreed to the published version of the manuscript.

**Funding:** This research was funded by the Apulia region, PO FEAMP Italy 2014–2020. EU regulations 1303/2013 and 508/2014. Priority axis 1. Measure 1.40—“Protection and Restoration of Marine Biodiversity and Ecosystems and Compensation Schemes in the Context of Sustainable Fisheries. Project of Protection and Management of *Paracentrotus lividus* and *Arbacia lixula*: An Intervention Strategy in the Apulian Adriatic Coast—Project name: TuGePIAl”. The APC was funded by UNIBA (University of Bari Aldo Moro).

**Informed Consent Statement:** The data collected through the online questionnaire were used exclusively for statistical purposes and for this study. They will not be disclosed to third parties or used for private interests, own or others, according to Regulation (EU) 2016/679 on the protection of individuals with regard to the processing of personal data. The acquired information was exclusively used in an aggregate way, thus guaranteeing the most complete anonymity of the respondent.

**Data Availability Statement:** Data are available from the corresponding author.

**Acknowledgments:** Thanks are due to Daniela Cuppone and Enza Campanella for their administrative support as well as to Meliadò Eleonora for her provision of sea urchins photos.

**Conflicts of Interest:** The authors declare no conflict of interest.

## Appendix A. “TuGePlAI” Apulia Project in Brief

Over the last 10 years, the Apulian fishing sector has shown a decisive and systematic decline, caused by the reduction in fishing efforts, both in terms of activity and capacity. The economic and environmental sustainability of the Apulian fishing fleet has been gradually reduced, highlighting the risks of a loss of economic efficiency in the sector and a growing impact on the maintenance of biodiversity. The project proposal is, therefore, the link between responsible fishermen and consumers attentive to sustainable nutrition and respectful of endangered species and the most exploited fish stocks. As such, the project aims to study and build a set of good sustainable fishing practices to be adopted and replicated in other territories. It is intended to promote the development of a system of protection, management, and enhancement of the stock of *Paracentrotus lividus* and *Arbacia lixula* in the “Regional Park of the Coastal Dunes” from Savelletri to Torre San Leonardo, increasing/maximizing, at the same time, the competitiveness and profitability in the regional fishing sector of reference. More details concerning this project and the survey questionnaire may be gathered from the following link: <https://www.tugeplai.it/> (accessed on 10 January 2023).

## References

- Lawrence, J.M. (Ed.) Edible Sea Urchin: Use and Life-History Strategies. Developments in Aquaculture and Fisheries Science. In *Edible Sea Urchin: Biology and Ecology*; Elsevier Science B.V.: Amsterdam, The Netherlands, 2007; Volume 37, pp. 1–9.
- Turon, X.; Giribert, G.; López, S.; Palacin, C. Grow and population structure of *Paracentrotus lividus* (Echinodermata: Echinoidea) in two contrasting habitats. *Mar. Ecol. Prog. Ser.* **1995**, *122*, 193–204. [CrossRef]
- Food and Agricultural Organization of the United Nations. General Fisheries Commission for the Mediterranean—GFCM. SoMFi. 2018. Available online: <https://www.fao.org/gfcm/publications/somfi/2018/en> (accessed on 15 July 2021).
- Ministero Dell’agricoltura, Della Sovranità Alimentare e Delle Foreste. Sea Fishing Logbook Dataset. 2021. Available online: <https://www.politicheagricole.it/flex/cm/pages/ServeBLOB.php/L/IT/IDPagina/8327> (accessed on 5 January 2023).
- Pais, A.; Chessa, L.A.; Serra, S.; Rui, A.; Meloni, G.; Donno, Y. The impact of commercial and recreational harvesting for *Paracentrotus lividus* on shallow rocky reef sea urchin communities in North-Western Sardinia, Italy. *Estuar* **2007**, *73*, 589–597. [CrossRef]
- Tilocca, M.G. Production Technology of Sea Urchin Pulp of the *Paracentrotus lividus* Species and Health Controls. Bachelor’s Thesis, University of Pisa, Pisa, Italy, 2015. Available online: <https://core.ac.uk/download/pdf/79622289.pdf> (accessed on 14 July 2021).
- Li, H.; Liao, F.; Qing, P. How consumer expertise influences preference for customized food. *Foods* **2022**, *11*, 2459. [CrossRef]
- Manalo, A.B.; Gempesaw, C.M. Preferences for oyster attributes by consumers in the US Northeast. *J. Food Distrib.* **1997**, *28*, 55–63.
- Pellaio, M.K.; Olivares-Arenas, M.; Puebla, L.; Marin Jarrin, J.R. Shifting demand to sustainable fishing practices in Darwin’s Archipelago: A discrete choice experiment application for Galapagos’ certified Yellow-fin tuna. *Mar. Policy* **2021**, *132*, 104665.
- Carlucci, D.; Nocella, G.; De Devitiis, B.; Viscecchia, R.; Bimbo, F.; Nardone, G. Consumer purchasing behaviour towards fish and seafood products. Patterns and insights from a sample of international studies. *Appetite* **2015**, *84*, 212–227. [CrossRef] [PubMed]
- Olsen, O.S. Understanding the relationship between age and seafood consumption: The mediating role of attitude, health involvement and convenience. *Food Qual. Pref.* **2003**, *14*, 199–209. [CrossRef]
- Wessells, R.C.; Johnston, R.J.; Donath, H. Assessing consumer preferences for Eco labeled seafood: The influence of species, certifier, and household attributes. *Am. J. Agric. Econ.* **1999**, *81*, 1084–1089. [CrossRef]
- Kenner, R.; Pearce, R.; Schlosser, E.; Robledo, M.; Pohlad, W.; Skoll, J.; Schorr, R.; Weyermann, D.; Pearlstein, E.; Roberts, K.; et al. *Food, Inc.*; Magnolia Home Entertainment: Los Angeles, CA, USA, 2009.
- Kingsolver, B.; Kingsolver, C.; Hopp, S.L. Animal, Vegetable, Miracle. In *Four Fish: The Future of the Last Wild Food*; Greenberg, P., Ed.; HarperCollins: New York, NY, USA; Penguin: New York, NY, USA, 2010.

15. Jaffry, S.; Glenn, H.; Ghulam, Y.; Willis, T.; Delanbanque, C. Are expectations being met? Consumer preferences and rewards for sustainably certified fisheries. *Mar. Policy* **2016**, *73*, 77–91. [\[CrossRef\]](#)
16. Claret, A.; Guerrero, L.; Aguirre, E.; Rincón, L.; Hernández, M.D.; Martínez, I. Consumer preferences for sea fish using conjoint analysis: Exploratory study of the importance of country of origin, obtaining method, storage conditions and purchasing price. *Food Qual. Prefer.* **2012**, *26*, 259–266. [\[CrossRef\]](#)
17. Lawley, M.; Birch, D.; Hamblin, D. An exploratory study into the role and interplay of intrinsic and extrinsic cues in Australian consumers' evaluations of fish. *Australas. Mark. J.* **2012**, *20*, 260–267. [\[CrossRef\]](#)
18. Hinkes, C.; Schulze-Ehlers, B. Consumer attitudes and preferences towards pangasius and tilapia: The role of sustainability certification and the country of origin. *Appetite* **2018**, *1*, 171–181. [\[CrossRef\]](#)
19. Pouta, E.; Heikkilä, J.; Forsman-Hugg, S.; Isoniemi, M.; Mäkelä, J. Consumer choice of broiler meat: The effects of country of origin and production methods. *Food Qual. Prefer.* **2010**, *21*, 539–546. [\[CrossRef\]](#)
20. Hempel, C.; Hamm, U. Local and/or organic: A study on consumer preferences for organic food and food from different origins. *Int. J. Consum. Stud.* **2016**, *40*, 732–741. [\[CrossRef\]](#)
21. Asche, F.; Larsen, T.A.; Smith, M.D.; Sogn-Grundvåg, G.; Young, J.A. Pricing of eco-labels with retailer heterogeneity. *Food Policy* **2015**, *53*, 82–93. [\[CrossRef\]](#)
22. Fonner, R.; Sylvia, G. Willingness to pay for multiple seafood labels in a niche market. *Mar. Resour.* **2015**, *30*, 51–70. [\[CrossRef\]](#)
23. Alfnes, F.; Guttormsen, A.G.; Steine, G.; Kolstad, K. Consumers' willingness to pay for the color of salmon: A choice experiment with real economic incentives. *Am. J. Agric. Econ.* **2006**, *88*, 1050–1061. [\[CrossRef\]](#)
24. Bi, X.; House, L.; Gao, Z. Impacts of nutrition information on choices of fresh seafood among parents. *Mar. Resour.* **2016**, *31*, 355–372. [\[CrossRef\]](#)
25. Gao, Z.; House, L.; Bi, X. Impact of satisficing behavior in online surveys on consumer preference and welfare estimates. *Food Policy* **2016**, *64*, 26–36. [\[CrossRef\]](#)
26. Bronnmann, J.; Asche, F. Sustainable seafood from aquaculture and wild fisheries: Insights from a discrete choice experiment in Germany. *Ecol. Econ.* **2017**, *142*, 113–119. [\[CrossRef\]](#)
27. Van Osch, S.; Hynes, S.; O'Higgins, T.; Hanley, N.; Campbell, D.; Freeman, S. Estimating the Irish public's willingness to pay for more sustainable salmon produced by integrated multi-trophic aquaculture. *Mar. Policy* **2017**, *84*, 220–227. [\[CrossRef\]](#)
28. Thong, N.T.; Solgaard, H.S.; Haider, W.; Roth, E.; Ravn-Jensen, L. Using labeled choice experiments to analyze demand structure and market position among seafood products. *Agribusiness* **2018**, *34*, 163–189. [\[CrossRef\]](#)
29. Weir, M.J.; Sproul, T.W. Identifying drivers of genetically modified seafood demand: Evidence from a choice experiment. *Sustainability* **2019**, *11*, 3934. [\[CrossRef\]](#)
30. Costanigro, M.; Onozaka, Y. A belief-preference model of choice for experience and credence goods. *J. Agric. Econ.* **2020**, *71*, 70–95. [\[CrossRef\]](#)
31. Menozzi, D.; Nguyen, T.T.; Sogari, G.; Taskov, D.; Lucas, S.; Castro-Rial, J.L.S.; Mora, C. Consumers' preferences and willingness to pay for fish products with health and environmental labels: Evidence from five European countries. *Nutrients* **2020**, *12*, 2650. [\[CrossRef\]](#) [\[PubMed\]](#)
32. Olesen, I.; Alfnes, F.; Røra, M.B.; Kolstad, K. Eliciting consumers' willingness to pay for organic and welfare-labelled salmon in a non-hypothetical choice experiment. *Livest. Sci.* **2010**, *127*, 218–226. [\[CrossRef\]](#)
33. Zhang, X.; Fang, Y.; Gao, Z. Accounting for Attribute Non-Attendance (ANA) in Chinese consumers' away-from-home sustainable salmon consumption. *Mar. Resour. Econ.* **2020**, *35*, 263–284. [\[CrossRef\]](#)
34. Zheng, Q.; Wang, H.H.; Shogren, J.F. Fishing or aquaculture? Chinese consumers' stated preference for the growing environment of salmon through a choice experiment and the consequentiality effect. *Mar. Resour. Econ.* **2021**, *36*, 23–42. [\[CrossRef\]](#)
35. Mueller Loose, S.; Peschel, A.; Grebitus, C. Quantifying effects of convenience and product packaging on consumer preferences and market share of seafood products: The case of oysters. *Food Qual. Prefer.* **2013**, *28*, 492–504. [\[CrossRef\]](#)
36. Chen, J.Q.; Haws, M.C.; Fong, Q.S.W.; Leung, P. Locally grown oysters in Hawai'i: Chef preference and local premium? *J. World Aquac. Soc.* **2017**, *48*, 972–980. [\[CrossRef\]](#)
37. Li, T.; Kecinski, M.; Messer, K.D. Heterogeneous preferences for oysters: Evidence from field experiments. *Agric. Resour. Econ. Rev.* **2017**, *46*, 296–314. [\[CrossRef\]](#)
38. Wakamatsu, H.; Miyata, T. Effects of radioactive safety information on consumer fears of radioactive contamination from oyster products in Japan. *Mar. Policy* **2021**, *126*, 104401. [\[CrossRef\]](#)
39. Wirth, F.; Love, L.; Palma, M. Purchasing shrimp for at-home consumption: The relative importance of credence versus physical product features. *Aquac. Econ. Manag.* **2007**, *11*, 17–37. [\[CrossRef\]](#)
40. Liu, T.-M.; Chen, I.-J.; Yuan, H.-C.J. Using stated preference valuation to support sustainable marine fishery management. *Sustainability* **2021**, *13*, 4838. [\[CrossRef\]](#)
41. Xuan, B.B. Consumer preference for eco-labelled aquaculture products in Vietnam. *Aquaculture* **2021**, *532*, 736111. [\[CrossRef\]](#)
42. Yin, S.; Wang, J.; Han, F.; Chen, M.; Yan, Z. Consumer preference for food safety attributes of white shrimp in China: Evidence from choice experiment with stated attribute non-attendance. *Food Control* **2022**, *137*, 108938. [\[CrossRef\]](#)
43. Ngoc, P.T.A.; Meuwissen, M.P.M.; Le, T.C.; Bosma, R.H.; Verreth, J.; Lansink, A.O. Adoption of recirculating aquaculture systems in large pangasius farms: A choice experiment. *Aquaculture* **2016**, *460*, 90–97. [\[CrossRef\]](#)

44. Nguyen, L.; Gao, Z.; Anderson, J.L.; Love, D.C. Consumers' willingness to pay for information transparency at casual and fine dining restaurants. *Int. J. Hosp. Manag.* **2022**, *100*, 103104. [CrossRef]
45. Davidson, K.; Pan, M.; Hu, W.; Poerwanto, D. Consumers' willingness to pay for aquaculture fish products vs. wild-caught seafood—A case study in Hawaii. *Aquac. Econ. Manag.* **2012**, *16*, 136–154. [CrossRef]
46. Lancaster, K.J. A new approach to consumer theory. *J. Political Econ.* **1966**, *74*, 132–157. [CrossRef]
47. Furesi, R.; Madau, F.A.; Palomba, A.; Pulina, P. Stated preferences for consumption of sea urchin: A choice experiment in Sardinia (Italy). *Int. J. Food Syst. Dyn.* **2014**, *5*, 111–119.
48. Petrontino, A.; Frem, M.; Fucilli, V.; Tricarico, G.; Bozzo, F. Health-nutrients and origin awareness: Implications for regional wine market-segmentation strategies using a latent analysis. *Nutrients* **2022**, *14*, 1385. [CrossRef] [PubMed]
49. Bliemer, M.C.J.; Rose, J.M.; Hess, S. Approximation of bayesian efficiency in experimental choice designs. *J. Choice Model.* **2008**, *1*, 98–127. [CrossRef]
50. Kleinegesse, S.; Gutmann, M.U. Efficient Bayesian experimental design for implicit models. In Proceedings of the 22nd International Conference on Artificial Intelligence and Statistics, Naha, Japan, 16–18 April 2019.
51. Annunziata, A.; Agnoli, L.; Vecchio, R.; Charters, S.; Mariani, A. Health warnings on wine labels: A discrete choice analysis of Italian and French Generation Y consumers. *Wine Econ. Pol.* **2019**, *8*, 81–90. [CrossRef]
52. Aschemann-Witzel, J.; Grunert, K.G.; van Trijp, H.C.; Bialkova, S.; Raats, M.M.; Hodgkins, C.; Wasowicz-Kirylo, G.; Koenigstorfer, J.E. Effect of nutrition label format and product assortment on the healthfulness of food choice. *Appetite* **2013**, *71*, 63–74. [CrossRef]
53. Ratliff, E.; Vassalos, M.; Hu, W. Assessing the influence of tangible and intangible seafood characteristics on consumers' purchasing decisions. In Proceedings of the 2007 Annual Meeting, Southern Agricultural Economics Association, Mobile, AL, USA, 4–7 February 2017. [CrossRef]
54. Garrod, G.; Ruto, E.; Powe, N. Investigating preferences for the local delivery of agri-environment benefits. *J. Agric. Econ.* **2014**, *65*, 177–190. [CrossRef]
55. Istituto Nazionale di Statistica. Italian Population in 2021. Available online: <https://dati.istat.it/> (accessed on 23 October 2021).
56. Select Statistical Services. Population Portion—Sample Size. Available online: <https://select-statistics.co.uk/calculators/sample-size-calculator-population-proportion/> (accessed on 23 October 2021).
57. Train, K.E. *Discrete Choice Methods with Simulation*, 2nd ed.; Cambridge University Press: Cambridge, United Kingdom, 2000; p. 400.
58. Onozaka, Y.; McFadden, D.T. Does Local Labeling Complement or Compete with Other Sustainable Labels? A Conjoint Analysis of Direct and Joint Values for Fresh Produce Claim. *Am. J. Agric. Econ.* **2011**, *93*, 693–706. [CrossRef]
59. Greene, W.H.; Hensher, D.A. A latent class model for discrete choice analysis: Contrasts with mixed logit. *Transport. Res. B Methodol.* **2003**, *37*, 681–698. [CrossRef]
60. Giosuè, C.; Gancitano, V.; Sprovieri, M.; Boscaino, G.; Vitale, S. A responsible proposal for Italian seafood consumers. *Eur. J. Sustain. Dev.* **2018**, *7*, 20. [CrossRef]
61. Bryła, P. The impact of consumer Schwartz values and regulatory focus on the willingness to pay a price premium for domestic food products: Gender differences. *Energies* **2021**, *14*, 6198. [CrossRef]
62. Yang, Y.; Hobbs, J.E.; Natcher, D.C. Assessing consumer willingness to pay for Arctic food products. *Food Policy* **2020**, *92*, 101846. [CrossRef]
63. Calvo-Porral, C.; Levy-Mangin, J.-P. Situational factors in alcoholic beverage consumption: Examining the influence of the place of consumption. *Br. Food J.* **2019**, *121*, 2086–2101. [CrossRef]
64. Lim, K.H.; Hu, W.; Nayga, R.M. Is Marine Stewardship Council's ecolabel a rising tide for all? Consumers' willingness to pay for origin-differentiated ecolabeled canned tuna. *Mar. Policy* **2018**, *96*, 18–26. [CrossRef]
65. Cantillo, J.; Martín, J.C.; Román, C. Discrete choice experiments in the analysis of consumers' preferences for finfish products: A systematic literature review. *Food Qual. Prefer.* **2020**, *84*, 103952. [CrossRef]
66. Bastounis, A.; Buckell, J.; Hartmann-Boyce, J.; Cook, B.; King, S.; Potter, C.; Bianchi, F.; Rayner, M.; Jebb, S.A. The impact of environmental sustainability labels on willingness-to-pay for foods: A systematic review and meta-analysis of discrete choice experiments. *Nutrients* **2021**, *13*, 2677. [CrossRef]
67. Risius, A.; Hamm, U.; Janssen, M. Target groups for fish from aquaculture: Consumer segmentation based on sustainability attributes and country of origin. *Aquaculture* **2019**, *499*, 341–347. [CrossRef]
68. Xia, L.; Chen, B.; Hunt, K.; Zhuang, J.; Song, C. Food Safety Awareness and Opinions in China: A Social Network Analysis Approach. *Foods* **2022**, *11*, 2909. [CrossRef]
69. Czarniecka-Skubina, E.; Stasiak, D.M.; Latoch, A.; Owczarek, T.; Hamulka, J. Consumers' Perception and Preference for the Consumption of Wild Game Meat among Adults in Poland. *Foods* **2022**, *11*, 830. [CrossRef]
70. Wang, H.; Chen, Q.; Zhu, C.; Bao, J. Paying for the Greater Good?—What Information Matters for Beijing Consumers' Willingness to Pay for Plant-Based Meat? *Foods* **2022**, *11*, 2460. [CrossRef]
71. Bianchi, R. Agricoltura e Multifunzionalità. La transizione ad un modello produttivo alternativo. *Econ. Ambiente* **2016**, *1*, 13–18.
72. Bianchi, R. Multifunctionality in Agriculture. New Productive Paths in the Primary Sector. *J. Agric. Life Sci.* **2018**, *5*, 1–7. [CrossRef]

**Disclaimer/Publisher's Note:** The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.

**CHAPTER 2: Blockchain Labelled Pasta and Consumer Preferences**  
(Published in *Frontiers in Sustainable Food Systems*)



## OPEN ACCESS

## EDITED BY

Isabelle Piot-Lepetit,  
INRAE Occitanie Montpellier, France

## REVIEWED BY

Zlati Monica Laura,  
Dunarea de Jos University, Romania  
Raffaella Pergamo,  
Council for Agricultural and Economics  
Research (CREA), Italy

## \*CORRESPONDENCE

Michel Frem

✉ mefrem@sinagrispinoff.it

RECEIVED 08 January 2024

ACCEPTED 19 February 2024

PUBLISHED 14 March 2024

## CITATION

Petrontino A, Frem M, Fucilli V, Tria E,  
Campobasso AA and Bozzo F (2024)  
Consumers' purchase propensity for pasta  
tracked with blockchain technology and  
labelled with sustainable credence attributes.  
*Front. Sustain. Food Syst.* 8:1367362.  
doi: 10.3389/fsufs.2024.1367362

## COPYRIGHT

© 2024 Petrontino, Frem, Fucilli, Tria,  
Campobasso and Bozzo. This is an open-  
access article distributed under the terms of  
the [Creative Commons Attribution License](#)  
(CC BY). The use, distribution or reproduction  
in other forums is permitted, provided the  
original author(s) and the copyright owner(s)  
are credited and that the original publication  
in this journal is cited, in accordance with  
accepted academic practice. No use,  
distribution or reproduction is permitted  
which does not comply with these terms.

# Consumers' purchase propensity for pasta tracked with blockchain technology and labelled with sustainable credence attributes

Alessandro Petrontino<sup>1</sup>, Michel Frem<sup>2\*</sup>, Vincenzo Fucilli<sup>1</sup>,  
Emanuela Tria<sup>1</sup>, Adele Annarita Campobasso<sup>1</sup> and  
Francesco Bozzo<sup>1</sup>

<sup>1</sup>Department of Soil, Plant and Food Sciences, University of Bari Aldo Moro, Bari, Italy, <sup>2</sup>Sinagri S.r.l., Spin Off of the University of Bari Aldo Moro, Bari, Italy

**Introduction:** Pasta is a key product in Italy's agri-food industry, consumed due to its ease of preparation, nutritional richness, and cultural importance. Evolving consumer awareness has prompted adaptations in the pasta market, to address concerns about social, environmental, quality, and food safety issues. This study examines Italian consumers' willingness to pay (WTP) for pasta in local markets, analysing their behaviours and preferences.

**Methods:** For this purpose, we used a discrete choice experiment (DCE) technique combined with a latent variable model. We also collected 397 valid online questionnaires.

**Results and Discussion:** The results reveal an interest utility among all respondents to pay a price premium of €1.16, €0.82, €0.62, €0.41, and €0.36 for 500 g of pasta, for the use of blockchain/QR code (BC) technology on the label, providing data on credence attributes such as safety, environmental and social sustainability as well as business innovative practices, respectively. As such, this research has private and public implications. On one hand, this research may bridge the scarcity in studies regarding consumer preferences and WTP for BC in the pasta value chain, preventing agricultural frauds, ensuring the sustainability and quality of agri-food products like pasta, and protecting and educating consumers through clear and transparent information. On the other hand, this research may incentivise pasta businesses to meet social and environmental consumers' demands while simultaneously enhancing their financial performance.

## KEYWORDS

blockchain technology, choice behaviour, food innovation, food safety and quality, food sustainability, food traceability information, willingness to pay (WTP)

## 1 Introduction

Pasta value chain constitutes a strategic Italian agri-food sector. With an average of 23 kg/capita/year, Italy is the universal leading country in pasta consumption in 2022 and has the first worldwide position in pasta production which is estimated near to 4 million tonnes in 2021 as depicted in [Tables 1, 2](#). Furthermore, Italy holds a share of 28.3% of the global dried pasta export, generating an export value of this category of foods of approximately 4 billion euro in 2022. In addition, Italy produces 3.8 million tonnes of durum wheat from 1.24 million

TABLE 1 Leading countries in pasta consumption in 2022 (kg per capita).

| Country                  | Average consumption (kg/capita/year) |
|--------------------------|--------------------------------------|
| Italy                    | 23                                   |
| Tunisia                  | 17                                   |
| Venezuela                | 15                                   |
| Greece                   | 12.2                                 |
| Peru                     | 9.9                                  |
| Chile                    | 9.6                                  |
| United States of America | 8.8                                  |
| Turkey                   | 8.7                                  |
| Iran                     | 8.5                                  |
| France                   | 8.3                                  |
| Germany                  | 7.9                                  |

Source: [www.statista.com/statistics/1379424/per-capita-consumption-pasta-by-country](https://www.statista.com/statistics/1379424/per-capita-consumption-pasta-by-country) (accessed on 07/11/2023).

TABLE 2 Leading countries in pasta production in 2021 (Tonnes).

| Country                  | Production (Tonnes) |
|--------------------------|---------------------|
| Italy                    | 3,890,467           |
| United States of America | 2,000,000           |
| Turkey                   | 1,902,423           |
| Egypt                    | 1,200,000           |
| Brazil                   | 1,182,000           |
| Russia                   | 1,096,912           |
| Nigeria                  | 700,000             |
| Iran                     | 560,000             |
| Argentina                | 407,336             |

Source: [www.statista.com/statistics/1378224/leading-countries-worldwide-in-pasta-production](https://www.statista.com/statistics/1378224/leading-countries-worldwide-in-pasta-production) (accessed on 07/11/2023).

hectares, mostly located in Apulia and Sicily regions (southern Italy), representing approximately 28 and 21% of the total cultivated area in durum wheat, respectively. Despite, it is important to spotlight how the country cannot meet the growing national demand. Thereby, Italy imports pasta and derivatives, with a total of 40.1 thousand tonnes, especially from China and Germany as presented in Table 3 (Statista, 2023). Consumed on a daily based in Italy, dried pasta and similar substances are considered as easy-to-cook, convenient, nutritious, and affordable food category items. However, their relative high carbohydrate contents may cause a barrier for their market growth, mainly for consumers over 50 years old (Pounis et al., 2016). In this direction, to attract and satisfy consumers, a wide variety of pasta is evolving, integrating different ingredients (i.e., carrots, herbs, beet, and legumes), and including innovative production processes such as organic, gluten-free, and vegan. However, the rising of environmental and social sustainability issues, the food frauds, the food quality and safety, and the impact of innovative technologies constitute continuously the major consumer concerns in the developed countries such Italy. As a result, all economical actors are joining their efforts to satisfy this increasing aware of consumers' requirements toward more traceable, sustainable, innovative, safe, and high-quality Italian pasta

products, inducing a greater consumer willingness to pay (WTP) (Rossi et al., 2023). On the contrary, a lower WTP to them may occur if they have modest information and awareness about safety and healthy features of pasta (Altamore et al., 2017). Thus, there is a need for new research to explore these consumers' requirements toward as well as their consumption of pasta.

In this direction, many studies have looked at food traceability, sustainability, innovation, and safety from a consumer behaviour perspective. Regarding the traceability issues, several research studies have explored the consumers' acceptability of blockchain traceability system (BT) as an innovative digital tracking food. Since 2008, the concept of the Internet of Things (IoT) was applied, to become a reality the application of electronic and real-time information sharing (Qian et al., 2020). Consumers' purchasing behaviour toward traceable food could change according to their perception of these technologies. In their studies, Spence et al. (2018), Yeh et al. (2019), and Lin et al. (2021) analysed consumers' intention to adopt BT toward the traceability of organic food products, indicating that BT influences positively and significantly their purchase decision. Therefore, BT is considered an important aspect in our research. In terms of sustainability issues, the determinants of consumer behaviour toward environmental and social sustainable pasta production were relatively less addressed in the literature review. In their study, Altamore et al. (2017) assessed consumers' preferences and opinions toward environmental issues associated with pasta in Sicily, in which the participants, evaluated very interesting the absence of toxins, related to climate conditions in Sicily. This could, therefore, be considered as an ecosystem service that would be useful to evaluate the adoption of sustainable and healthy agricultural models, as suggested by Mediterranean diet. Furthermore, it is crucial to inform consumers how the food traceability system works to gain consumers' trust in food safety and to build their confidence in it. This consideration was also exposed by Bandinelli et al. (2023), who considered that BT can constitute an important tool, but the mechanism that regulates it must be correctly communicated, so that the consumers can understand its effectiveness in guaranteeing transparency and accountability. Practically, the use of IoT sensors gathers both field and meteorological information about durum wheat production and uploads them into Hyperledger Fabric (Fiore et al., 2023, 2024). An edge computing unit is responsible of converting this huge amount of data into valuable information; then, it uploads the output of the processing to Ethereum. Growers also upload some information about the wheat production (i.e., where it is produced and how it is transported from the field to the cooperative). A consumer, looking at the pasta package in a supermarket, decides to know more about this food. He may open the web app and scans the QR code that he finds on the pasta label. He then retrieves all relevant information about a lot of pasta product, at different stages of the value chain (Galvez et al., 2018), such as: stage of production (i.e., gathering information on but not limited to: varieties, agricultural practices such as the use of the pesticides, fertilisers, or any other agricultural practices that have been applied during the cultivation process, timing, production area, and working conditions); stage of processing (i.e., gathering data on but not limited to: operations conditions, packaging, process of fabrication, safety, and quality assurance); stage of storage (i.e., retrieving data on but not limited to: the quantity, temperature, and humidity); and stage of distribution (i.e., getting data on real-time environmental data of transport and storage, location of the distribution vehicles,

**TABLE 3** Leading suppliers of Italy's imports of pasta in 2022 (million euros).

| Country     | Importation (million euros) |
|-------------|-----------------------------|
| China       | 14.83                       |
| Germany     | 12.76                       |
| Belgium     | 12.34                       |
| Poland      | 9.89                        |
| France      | 7.63                        |
| Netherlands | 6.89                        |
| Greece      | 4.61                        |
| Austria     | 4.48                        |
| South Korea | 4.41                        |
| Serbia      | 4.05                        |

Source: [www.statista.com/statistics/1027841/leading-suppliers-of-italy-s-imports-of-pasta](https://www.statista.com/statistics/1027841/leading-suppliers-of-italy-s-imports-of-pasta) (accessed on 07/11/2023).

transportation timing, and quality control). Consequently, the advantages that the application of BT in a food supply such pasta value chain can bring are many and involve both consumers and producers in terms of: transparency and authenticity of data; security, as the problem of fraud is kept under control; decentralisation; automation and consequent reduction of administrative costs and bureaucratic practices; recognition of goods that do not comply with safety standards and consequent withdrawal of goods from the market; and identification of the true origin of the products as well as the reduction of counterfeiting and falsification of pasta products. In addition, the use of BT technology implements the social sustainability of the pasta, emerging many social elements. In fact, the social sustainability encompasses a series of manoeuvres that aim mainly to ensure a comfortable and dignified life for workers without any distinction between them. In this direction, the social sustainability of pasta products will involve a significant commitment on the part of agricultural households, especially in terms of enhancing human capital through carrying out professional and extra-professional training activities for workers as well as transparency toward illegal work and fair retribution. Furthermore, other potential elements may emerge through this sustainability dimension in terms of: (i) occupational safety, leading to personnel safety training activities, controls, and certifications; (ii) health insurance, prevention, and assistance services; (iii) potential pension funds and insurance policies for workers; (iv) initiatives for the reconciliation of work with personal needs such as leave and flexibility of hours, support for parents for the management of children, facilitations for meals, transport, and accommodation; and (v) initiatives to support immigrant workers for housing facilities, bureaucratic facilitations, and language training.

With respect to innovation issues, numerous scientific studies have addressed the determinants that affect consumers' perception and estimated the WTP by type of pasta toward this attribute. To examine whether increased vegetable variety enhances healthy food choices and improves meal composition, [Bucher et al. \(2011\)](#) have used a randomised experiment, in which participants tend to select an assortment of pasta and vegetables, inducing a balance meal and improving their food selection. In their studies, [Foschia et al. \(2014\)](#) explored the variation in the preparation processes of pasta made by durum wheat pasta (as a control) and pasta made with durum wheat

semolina and pea flour combinations, to assess the quality and to identify the best predictive *in vitro* glycaemic response in terms of starch degradation. Based on WTP, [Pappalardo et al. \(2017\)](#) have evaluated the economic feasibility of high heat treatments, a physical eco-friendly method for pest control in industrial plants that produce pasta in Sicily (Italy), increasing the factory's turnover and reducing the environmental impact. In their research, [Pasdar et al. \(2017\)](#) elucidated the compliance between information presented in food labelling of widely consumed foods such as pasta and their true values, inducing misleading effects on food choice and leading to public unhealthy eating. In addition, [Predieri et al. \(2018\)](#) explored the Italian older adults' consumers toward the development of innovative and healthy pasta sauces. [Van der Stricht et al. \(2023\)](#) studied WTP for front-of-pack labels on microalgae protein pulps. In their studies, [Stasi and Baino \(2023\)](#) assessed consumers' desires and willingness to purchase five frozen gnocchi formulations, while [Palmieri et al. \(2021\)](#) analysed consumers' WTP for a novel functional pasta based on *Opuntia Ficus Indica*. Furthermore, a small number of studies have looked at consumer preferences for the characteristics of pasta as it is. In this direction, [Cavallo et al. \(2014\)](#) conducted a real-world choice experiment considering 10 main intrinsic and extrinsic attributes (i.e., local origin, labelling, organic certification, and branding) of pasta. Finally, [Castellini et al. \(2022\)](#) stated that the acceptance of new food traceability technologies has shown that individual factors are the ones that most influence acceptability.

In this context, the present study will explore the behaviour, preferences, and purchasing decisions of Italian consumers and estimate their WTP toward pasta sold in the Italian markets. Precisely, this research focussed on dried pasta and aimed to answer to the following scientific questions: (i) What are Italian consumers' attitude and propensity toward consuming dried pasta? (ii) What are their WTP for the presence of the blockchain technology/QR code (hereafter, BC) on the pasta label as an implemented digital tool of traceability? (iii) What are their WTP toward the provision of additional labelling information associated to the environmental sustainability conditions (hereafter, IE), social sustainability issues (hereafter, IS), quality, and safety aspects (hereafter, IQ), and to the innovation business practices (hereafter, IN) used to produce pasta in Italy? (iv) How do their beliefs on food traceability and attention to credence food attributes such pasta, influence their consumption behaviour and purchase decision?

In summary, the originality and relevance of this research might be envisaged in different dimensions. First, there is a dearth of research that have explored the Italian consumer behaviour, propensity, and WTP toward the concerned attributes associated with pasta among the most internationally traded food products, as synthesised in [Table 3](#). For these purposes, we used simultaneously a discrete choice experiment (DCE) approach by means of a mixed logit model (MXL), and a latent variable model estimated within the structural equation model ([Ali et al., 2021; Figure 1](#)). Therefore, the remainder of the study is structured into six sections. The next section provides a brief outline of the econometric conceptual framework used for pasta choice. The subsequent section describes the DCE, MXL, and SEM models, in which the choice variables and the data collection survey are also stressed. The results are presented in section four and are followed by the discussion and limitations of the research in section 5. The concluding remarks are highlighted in the final section.

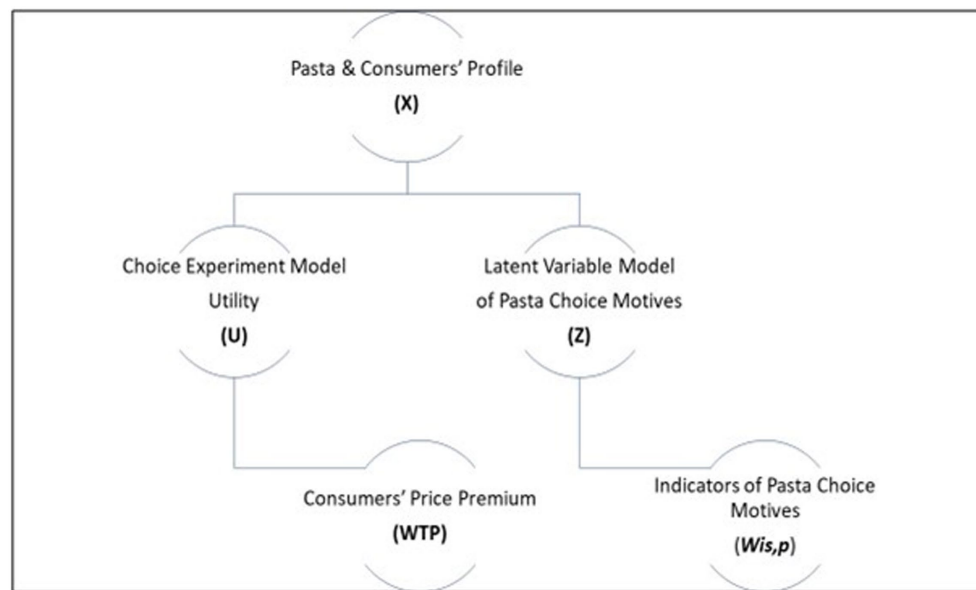


FIGURE 1  
Conceptual framework used in the analysis based on Ali et al. (2021).

## 2 Materials and methods

### 2.1 Choice experiment model: consumers' utility

The DCE is commonly applied to (i) explore decision choices in economy (Friedel et al., 2022), (ii) elicit consumers' preferences in marketing research, and (iii) estimate their WTP toward food product characteristics (Petrontino et al., 2022). DCE has also been adequately used in the literature in different contexts to explore pasta consumption. The DCE model involves the following stages: (i) selection of the attributes and the assignment of levels, (ii) experimental design and construction of choice sets, (iii) elaboration of a social questionnaire, (iv) sampling of respondents and survey, (v) econometric data analysis and estimation of the WTP, as described below. Furthermore, the DCE is based on the random utility maximisation (McFadden, 1974), assuming that a consumer would gain a utility from (Equation 1) a food product such as pasta. As such, the utility ( $U_{nj}$ ) is modelled as follows:

$$U_{nj} = \text{No buy} + \beta X_{nj} + \text{price } \lambda_j + \varepsilon_{nj} \quad (1)$$

where "No buy" is an alternative specific constant (ASC) representing the no-purchase option,  $X_j$  denotes the vector for each alternative  $j$ , containing different attributes (BC, IE, IS, IQ, IN) coded as dummy variables,  $\beta$  is a vector of the coefficients associated with each attribute, price is the price vector, and  $\lambda$  is the effect of price on utility (Equation 2). The  $\varepsilon_{nj}$  is the unobserved error term. Heterogeneity in preferences can be considered in the choice model including interaction terms representing the attitudes and beliefs of the consumers as latent variables.

$$U_{nj} = \text{No buy} + \beta X_{nj} + \text{price } \lambda_j + \gamma X_{nj} Z_n + \varepsilon_{nj} \quad (2)$$

where  $Z_n$  is the vector of the latent variables scores of  $n$ -th respondent, and  $\gamma$  is the effect of this characteristic on the utility function.

### 2.2 Latent variable model: heterogeneity of consumers' preferences

Assuming that utility function is individually determined and that psychographic variables are determinants in the behaviour of each respondent, a structural equation model (SEM) was structured to test the relationships between "closeness to blockchain technology" and the psychographic consumers' latent variables, namely, "attention to credence attributes" and "beliefs on traceability" (Rungie et al., 2012). SEM comprises a system of linear equations that concurrently assess the connections between observable variables, which are measurable items, and the unobservable constructs evaluated by these items. An essential practical benefit of employing SEM for data analysis is its capability to unveil relationships between latent variables that remain unobservable but can be deduced from observable variables. In this direction, the main underlying hypothesis is that the latent constructs of opinion and beliefs can explain the differences in preferences across respondents, resulting in a more efficient and parsimonious model. Since the latent characteristics are not directly observed, a set of  $k$  responses to the questions (items) are functions of the latent variables.  $Z_n$  scores are then estimated through a measurement model that implies the weights of the single items contributing to the latent variables, according to the set of equations where the values of the  $I_{kn}$  indicators (Equation 3) are dependent on the value of the related latent variable:

$$I_{kn} = \delta I_k + \zeta I_k Z_n + u_{kn} \tag{3}$$

where  $\delta I_k$  is a constant for the  $k$ -th indicator,  $\zeta I_k$  is the estimated effect of the latent variable  $Z_n$  on this indicator, and  $u_{kn}$  is a disturbance term that is assumed to be normally distributed.

### 2.3 Choice variables: attributes and levels

In the DCE approach, attributes are referred to as choice variables, factors, or features used by scientists to describe adequately the consumer’s decision outcome in a hypothetical situation (Friedel et al., 2022). Within each choice attribute, a few numbers of levels are assigned that could be qualitative or quantitative. In our DCE, we choose six attributes (i.e., BC, IE, IS, IQ, IN with 2 levels each, and Price with 3 levels as depicted in Table 4), using a focus group of technical experts, and considering their importance and negligence in terms of traceability for Italian consumers (Petrontino et al., 2023a). In fact, the traceability was often analysed with respect to the food safety and security issues and is considered relatively decisive in marketing strategies that may help to improve the performance of the pasta market. Regarding the social sustainability, we also considered that this attribute is often neglected compared to environmental sustainability and business innovation practices and could influence consumers’ purchase decision and their WTP. The price was considered in this study as discrete variable (Petrontino et al.,

2022), and its levels were assigned to cover the current different retail selling prices of the most popular Italian pasta packs of 500 g.

### 2.4 Designing choice sets and data collection: experimental design and social questionnaire

A combination of levels for each attribute (Table 5) is presented to each respondent. Given the excessive number of combinations (i.e.,  $2^5 \times 3^1 = 96$  alternatives), a D-efficient optimal design has been implemented, resulting in 2 blocks with 6 choice sets and 2 alternatives. Accordingly, we elaborated and divided the questionnaire into three different sections. The first section explored respondents’ attitudes and propensity toward the consumption and purchase of pasta, along with 9 questions such as the following: “What is your frequency of pasta purchase? (i.e., once a day; more than once a week; once a week; more than once a month; once a month; less than once a month; never)” (Q1); “Where do you habitually purchase dried pasta? (i.e., hypermarkets, supermarkets, discount shops, pasta factories, local shops, online (e-commerce), other)” (Q2); “When purchasing dried pasta, how much attention (low, medium, and high) do you pay for the following features: price, information labelling, nutritional facts, brand, presence of organic certification, presence of origin certification, and mode of packaging” (Q3); “According to your personal experience, how much (high, medium, or low) of the following characteristics affect the price of dried pasta: origin,

TABLE 4 Attributes and levels assigned in our discrete choice experiment for pasta.

| Attribute                                                                                                                                       | Level                                  |
|-------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------|
| Blockchain Technology<br><br>(Code: BC)<br>                  | 1 Presence<br>2 Absence                |
| Information on the environmental sustainabilityCode: IE<br>  | 1 Presence<br>2 Absence                |
| Information on the social sustainability<br><br>Code: IS<br> | 1 Presence<br>2 Absence                |
| Information on the quality & safety<br><br>Code: IQ<br>      | 1 Presence<br>2 Absence                |
| Information on the innovation<br><br>Code: IN<br>            | 1 Presence<br>2 Absence                |
| Price<br>Code: Price                                                                                                                            | 1 EUR 1.20<br>2 EUR 2.40<br>3 EUR 3.00 |

TABLE 5 Example of a set choice shown to respondent.

| Dried pasta                                                                       | Attribute & Code                                                   | Option "A"<br>Alternative "A"                                                                | Option "B"<br>Alternative "B"                                                                    | Option "C"<br>Alternative "C"<br>(No option/No buy) |
|-----------------------------------------------------------------------------------|--------------------------------------------------------------------|----------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------|-----------------------------------------------------|
|  | Blockchain Tecnology<br><b>Code: BC</b>                            | Present<br> | Absent                                                                                           | Neither "A" nor "B"                                 |
|                                                                                   | Information on the environmental sustainability<br><b>Code: IE</b> | Absent                                                                                       | Present<br>   |                                                     |
|                                                                                   | Information on the social sustainability<br><b>Code: IS</b>        | Present<br> | Absent                                                                                           |                                                     |
|                                                                                   | Information on the quality & safety<br><b>Code: IQ</b>             | Absent                                                                                       | Present<br>   |                                                     |
|                                                                                   | Information on the innovation<br><b>Code: IN</b>                   | Absent                                                                                       | Present<br> |                                                     |
|                                                                                   | Price<br><b>Code: Price</b>                                        | 3,00€                                                                                        | 1,50€                                                                                            |                                                     |
| Which option/alternative do you select?                                           |                                                                    | <input type="checkbox"/>                                                                     | <input type="checkbox"/>                                                                         | <input type="checkbox"/>                            |

purchase site, promotion strategy, qualitative characteristics of the product and characteristics related to the process of production" (Q4); "Which of the following sentences identifies better your behaviour in relation to the purchase of dried pasta: I am willing to buy a larger amount of pasta if the price is low; I am willing to pay a price premium if the pasta is safe and certified; I prefer an adequate quality/price, without caring about the safety of the product" (Q5); Express your level of consent (Strongly disagree; disagree; neither agree nor disagree; agree; strongly agree) related to the transparency of operations along the pasta value chain such a greater transparency of operations along the pasta value chain offer: a guarantee on the quality of the product; social benefits (i.e., respect of the job contract, undeclared work, reduction of labour exploitation, etc.); Environmental benefits (i.e., reduction of gas emissions, better efficiency in the use of water and energy, reduction of food waste, etc.); Benefits in terms of traceability of the production and food safety; An increase of innovation in the agricultural sector (i.e., use of sensors IoT, GPS, drones, etc.), offering benefits in terms of food security" (Q6); "Have you heard about the blockchain technology?" (Q7). "Are you aware (not all; a little, enough; a lot; very much) about blockchain technology associated to agri-food products?" (Q8); "What is your frequency (not all; a little, enough; a lot; very much) of agri-food purchase tracked with the blockchain technology?" (Q9).

The second section of the questionnaire was introduced by a chip talk scripts (Tonsor and Shupp, 2011; Van Loo et al., 2011; Dahlhausen et al., 2018; Jürkenbeck, 2023) describing the selected attributes and providing an example of a set choice (Table 4) to help the respondent in his decision process. Consequently, we presented an adequate number of 6 purchase simulations (i.e., set choice/task choice, Table 4) to prevent respondent fatigue (Hess et al., 2012; Dahlhausen et al., 2018; Petrontino et al., 2023b) and in which each respondent had to select between 2 alternatives (A, B) among each task choice that differed in the presence or absence on the label of the studied product the following: (i) QR code that reflects the blockchain technology, (ii) information on the environmental sustainability issues associated with the production of dried pasta, (iii) information on the social sustainability conditions associated with the production of dried pasta, (iv) information on the quality and safety production, (v) information of the innovation process of dried pasta production, and (vi) price. In addition, the set choice included a no buy option (C) in which we used pictograms reflecting the presence of the concerned attributes (Petrontino et al., 2023a).

The third section revealed the socio-demographic and economic profile of the respondents (i.e., gender, age, residence, civil status, family composition, level of education, work position, work sector, and annual household income).

## 2.5 Sampling: participants' survey

We carried out an online survey (Survey Monkey, 2023), from June to September 2023, covering the population living in Italy, and engaging 397 valid pasta respondents, considering the Italian population age, gender repartition, and annual household income, in which the sample was in a similar range to the main statistics of Italian population (Istituto Nazionale di Statistica – ISTAT, 2023) as reported in Table 6. Thus, the respondents in the survey were the main responsible for shopping for food for household consumption. For this purpose, we used the Equation 4 considering a margin of error 5%, and a confidence level of 95%, in which we calculated a sample size of 384 respondents and then we decided to increase this value to 400, and finally, we retained 397 valid respondents. Furthermore, the data collected through the online questionnaire were used exclusively for statistical purposes and for this study. They will not be disclosed to third parties or used for private interests, own or others, according to Regulation (EU) 2016/679 on the protection of individuals regarding the processing of personal data. The acquired information was exclusively used in an aggregate way, thus guaranteeing the most complete anonymity of the respondent. Furthermore, the consent from the participants was requested, at the beginning of the survey, to participate in this study in accordance with the national legislation and the institutional requirements.

$$n = \frac{\frac{z^2 * p(1-p)}{e^2}}{1 + \left( \frac{z^2 * p(1-p)}{e^2 N} \right)} = \frac{\frac{1.96^2 * 0.5(1-0.5)}{(0.05)^2}}{1 + \left( \frac{1.96^2 * 0.5(1-0.5)}{(0.05)^2 * 48\,021\,983} \right)} \quad (4)$$

$$= \frac{384.16}{1.00008} = 384$$

Where  $n$  is the sample size,  $N$  is the population size over 18 years old ( $N = 48,021,983$  in the first of January 2023 based on ISTAT 2023),  $e$  is the margin of error (percentage in decimal form: 5%),  $z$  is the  $z$ -score ( $z = 1.96$  for a desired confidence level of 95%), and  $p$  is the standard deviation ( $p = 0.5$ ).

## 2.6 Data analysis: statistical and econometric analysis

On the one hand, DCE was analysed with the econometric software Nlogit version 5, and Krinsky-Robb method with 500 draws has been utilised to estimate the WTP for each attributes according to their coefficients obtained in MXL model. The weights and the standard deviation of the items belonging to the respective latent variables contributed to calculate the scores to be used in the MXL model as interaction terms with the attributes of DCE. On the other hand, SEM was analysed using the partial least square structural equation modelling tool of the software JASP version 0.17.1.0. The latent variable “closeness to blockchain technology” (BLO) has been putted in relation with the following two latent variables “attention to credence attributes” (ATT) and “beliefs on traceability” (TRA), assuming that BLO is influenced by TRA and ATT while TRA is also influenced by ATT as shown in the Figure 2. After an accurate analysis

TABLE 6 Sample of Italian respondents used in our discrete choice experiment for pasta.

| Variable                       | Category                | Italian population | Sample |        |
|--------------------------------|-------------------------|--------------------|--------|--------|
|                                |                         |                    | Number | %      |
| Age (year)                     | 18 ≤ Age ≤ 44           | 29.74%             | 159    | 40.05  |
|                                | 45 ≤ Age ≤ 64           | 30.84%             | 171    | 43.07  |
|                                | > 64                    | 23.80%             | 67     | 16.88  |
| Gender                         | Male                    | 48                 | 183    | 46.10  |
|                                | Female                  | 52                 | 214    | 53.90  |
| Annual household income in EUR | Income ≤20.000          | 31,600             | 92     | 23.17  |
|                                | 20.000 > Income ≤40.000 |                    | 207    | 52.14  |
|                                | Income >40.000          |                    | 98     | 24.69  |
| Total – Sampling size          |                         |                    | 397    | 100.00 |

Source: Our elaboration and ISTAT, 2023.

of the model fit indexes, internal and external reliability, and significance of the settled relations, the composition of the latent construct has been defined as follows. BLO latent variable comprises the two items derived from the question Q7 and Q9. ATT latent variable comprises the four items derived from the question Q3, namely, the presence of organic certification (A\_Organic), the presence of origin certification (A\_Origin), nutritional facts (A\_Nutrition), and information labelling (A\_label). TRA latent variable comprises the three items derived from the question Q6, namely, benefits in terms of traceability of the production and food safety (T\_Trace), social benefits (T\_Social), and an increase of innovation in the agricultural sector (T\_innovation).

## 3 Results

### 3.1 Descriptive results: respondents' attitudes and propensity

This section presents the main descriptive statistics results related to the parts 1 and 2 of the online questionnaire survey toward the respondents' attitudes and propensity to purchase food such as dried pasta as well as their socio-economic profile. As a result, supermarkets were the most popular places of purchase of such category of food (28.72%), followed by hypermarkets (19.40%) and discount markets (11.59%), more than once a week as depicted in Table 7. Moreover, approximately 50% of the respondents in this survey conferred a high self-level of attention toward the price of the products and the importance of labelling information, nutritional facts, a medium self-level of attention regarding the nutritional facts, the presence of the origin certification, and the mode of packaging, which indicates that their purchase behaviour was mainly influenced by these product attributes as illustrated in Table 8. With respect to their self-level of experience with the level of influence of pasta features on its purchase price (Table 9), 34.26% of the respondents believed that the aspect of this food category influenced its purchase price, but approximately 10% of them were convinced that the purchase site or the promotional strategy presented relatively a low level of influence on its purchase price. In addition, most of respondents were willing to pay a “price

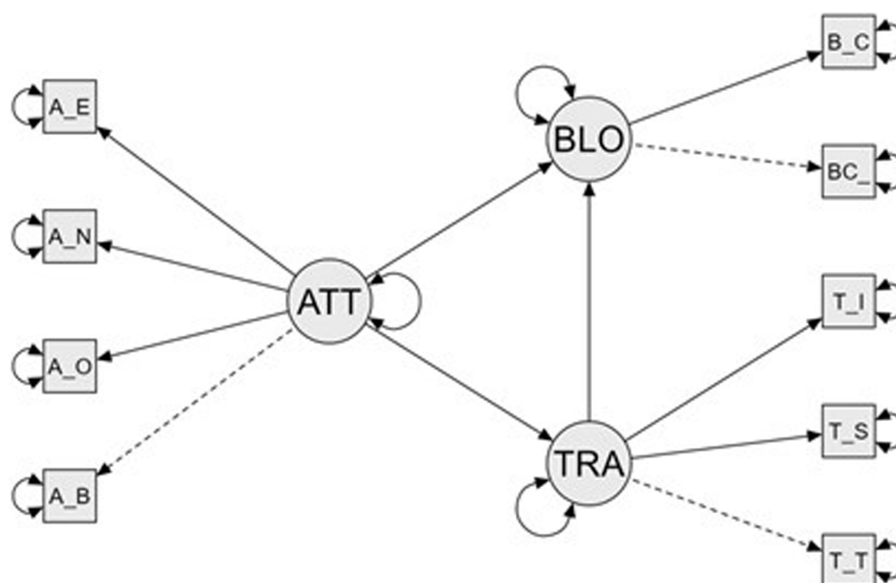


FIGURE 2

Relation between the latent variable “closeness to blockchain technology” (BLO) and the two latent variables “Attention to credence attributes” (ATT) and “Beliefs on traceability” (TRA).

TABLE 7 Purchase sites by frequency of pasta purchase (in number N and % of respondents).

| Place of purchase   | Frequency of purchase (number of purchase) |      |                       |       |             |       |                        |      |              |   |                        |   |       |   |
|---------------------|--------------------------------------------|------|-----------------------|-------|-------------|-------|------------------------|------|--------------|---|------------------------|---|-------|---|
|                     | Once a day                                 |      | More than once a week |       | Once a week |       | More than once a month |      | Once a month |   | Less than once a month |   | Never |   |
|                     | N                                          | %    | N                     | %     | N           | %     | N                      | %    | N            | % | N                      | % | N     | % |
| Hypermarkets        | 20                                         | 5.04 | 77                    | 19.40 | 27          | 6.80  | 2                      | 0.50 | 0            | 0 | 0                      | 0 | 0     | 0 |
| Supermarkets        | 23                                         | 5.79 | 114                   | 28.72 | 41          | 10.33 | 1                      | 0.25 | 0            | 0 | 0                      | 0 | 0     | 0 |
| Discount shops      | 8                                          | 2.02 | 46                    | 11.59 | 17          | 4.28  | 2                      | 0.50 | 0            | 0 | 0                      | 0 | 0     | 0 |
| Pasta factories     | 1                                          | 0.25 | 4                     | 1.01  | 0           | 0.00  | 0                      | 0.00 | 0            | 0 | 0                      | 0 | 0     | 0 |
| Local shops         | 4                                          | 1.01 | 3                     | 0.76  | 1           | 0.25  | 0                      | 0.00 | 0            | 0 | 0                      | 0 | 0     | 0 |
| Online (e-commerce) | 3                                          | 0.76 | 1                     | 0.25  | 0           | 0.00  | 0                      | 0.00 | 0            | 0 | 0                      | 0 | 0     | 0 |
| Other               | 0                                          | 0.00 | 1                     | 0.25  | 1           | 0.25  | 0                      | 0.00 | 0            | 0 | 0                      | 0 | 0     | 0 |

premium” if the dried pasta was safe and certified, followed sequentially by its other attributes, such as its adequate quality/price report, and its relative lower price as revealed in Table 10. The research was also explored into Italian consumer awareness and purchase frequency of agri-food tracked with BC, adopting a five-point Likert scale range, with 1 representing “not at all” or “never” and 5 “very much” or “always” as illustrated in Tables 10, 11. Consequently, very few respondents were very much (3.53%) or a lot (9.57%) aware about blockchain technology and were always (1.26%) or often (8.56%) purchased agri-food products tracked with digital BC as depicted in Tables 11, 12.

Despite these results, most of respondents agreed that a greater transparency of operations along the value chain, through the use of BC, offered the following: (i) a guarantee on the quality of the product such as dried pasta (52.14% of respondents), (ii) social benefits in terms of the respect of the job contract, undeclared work, and

reduction of labour abuse (54.66% of respondents), (iii) environmental benefits in terms of reduction of gas emissions, a better efficiency in the use of water and energy, reduction of food waste, etc. (51.89% of respondents), (iv) benefits in terms of traceability of the production and food safety (56.68% of respondents), and (v) an increase of innovation within the agriculture sector, offering more benefits in terms of food security (48.61% of respondents). For this issue, we also adopted a five-point Likert scale range, with 1 representing “not at all” or “never” and 5 “very much” or “always” as depicted in Table 13.

### 3.2 Latent construct: reliability and validity

The latent construct settled to produce the interaction terms to be used in the econometric model as resulted in the following paragraphs has been preliminarily verified in terms of internal

**TABLE 8 Respondents' self-level attention on the characteristics of pasta (in number N and % of respondents).**

| Pasta feature                     | Level of attention |       |        |       |      |       |
|-----------------------------------|--------------------|-------|--------|-------|------|-------|
|                                   | Low                |       | Medium |       | High |       |
|                                   | N                  | %     | N      | %     | N    | %     |
| Price                             | 8                  | 2.02  | 190    | 47.86 | 199  | 50.13 |
| Information labelling             | 28                 | 7.05  | 182    | 45.84 | 187  | 47.10 |
| Nutritional facts                 | 50                 | 12.59 | 199    | 50.13 | 148  | 37.28 |
| Brand                             | 41                 | 10.33 | 176    | 44.33 | 180  | 45.34 |
| Presence of organic certification | 82                 | 20.65 | 209    | 52.64 | 106  | 26.70 |
| Presence of origin certification  | 69                 | 17.38 | 185    | 46.60 | 143  | 36.02 |
| Mode of packaging                 | 79                 | 19.90 | 208    | 52.39 | 110  | 27.71 |

**TABLE 9 Respondents' self-level experience with the level of influence of pasta features on its purchase price (in number N and % of respondents).**

| Pasta feature                              | Respondents |        |
|--------------------------------------------|-------------|--------|
|                                            | N           | %      |
| Origin of the pasta                        | 95          | 23.93  |
| Purchase site                              | 40          | 10.08  |
| Promotion strategy (publicity, flyers)     | 43          | 10.83  |
| Qualitative characteristics of the product | 136         | 34.26  |
| Characteristics related to the process     | 82          | 20.65  |
| Total                                      | 396         | 100.00 |

consistency, reliability, and discriminant validity (Table 14). Factor loadings and average variance extracted (AVE) values show a satisfactory convergent validity of the items used in the construct. In addition, the reliability of the construct, as shown in Table 15, is high.

### 3.3 Econometric results

#### 3.3.1 Pasta consumers' preferences

The estimation results from the multinomial logit model (MNL), MXL model, and MXL model including interaction with psychographic terms are reported in Table 16. MXL model with interactions looks to be the more adequate model to explain the consumer choices because it shows improvements in terms of likelihood and information criterion. The coefficient for the price is both negative and statistically significant in all the elaborations, mirroring a discernible impact on consumer choice. Similarly, the no buy option exhibits a noteworthy negative coefficient. Furthermore,

**TABLE 10 Respondents' behaviour related to pasta purchasing (in number N and % of respondents).**

| Pasta feature                                                                      | Respondents |        |
|------------------------------------------------------------------------------------|-------------|--------|
|                                                                                    | N           | %      |
| I am willing to buy a larger amount of pasta if the price is low                   | 39          | 9.82   |
| I am willing to pay a price premium if the pasta is safe and certified             | 218         | 54.91  |
| I prefer an adequate quality/price. Without caring about the safety of the product | 140         | 35.26  |
| Total                                                                              | 396         | 100.00 |

**TABLE 11 Respondents' awareness about blockchain technology (in number N and % of respondents).**

| Level      | Respondents |        |
|------------|-------------|--------|
|            | N           | %      |
| Not at all | 107         | 26.95  |
| A little   | 143         | 36.02  |
| Enough     | 95          | 23.93  |
| A lot      | 38          | 9.57   |
| Very much  | 14          | 3.53   |
| Total      | 396         | 100.00 |

the estimated standard deviations for all attributes markedly differ from zero, signifying substantial heterogeneity in consumer preferences for blockchain technology, alongside information pertaining to the environment, social factors, quality, and innovation. The attributes related to blockchain technology and information on pasta production have always positive and significant coefficients, meaning that consumers retrieve utility from this kind of information. The most appreciated attribute is IQ letting believe that consumers are interested mostly in quality information on the food product. The effect of "attention to credence attributes" and "beliefs on traceability" on consumer preferences for all the attributes is included by interaction terms. Looking at the results that come from the interaction between MXL model attributes and the scores of the latent construct, it looks that those consumers that have a stronger belief on benefits of traceability show a greater preference for blockchain technology and the information on environment and quality of pasta. On the contrary, those consumers that pay more attention to credence attributes have a greater preference for social information and innovation of production.

#### 3.3.2 Pasta consumers' willingness to pay

Table 16 summarises the consumer's WTP per attribute type, in which respondents are willing to pay extra EUR 1.16, 0.82, 0.62, 0.41, and 0.36 per 500 g of pasta for a complete information of pasta safety, environmental sustainability, blockchain technology/QR code, innovation business, and social sustainability, respectively. As

such, the highest WTP is determined by the “food safety” attribute (average price premium of EUR 1.16/500 g), while the least WTP is determined by the “social sustainability information” (average price premium of EUR 0.36/500 g), indicating that food safety appears to be the most critical consumers’ concerns among the concerned attributes. However, these WTP differences across pasta attributes and consumers are statistically significant as depicted in Table 17.

**TABLE 12** Respondents’ purchase frequency of agri-food products tracked with the blockchain technology (in number N and % of respondents).

| Level      | Respondents |        |
|------------|-------------|--------|
|            | N           | %      |
| Not at all | 147         | 37.03  |
| A little   | 95          | 23.93  |
| Enough     | 116         | 29.22  |
| A lot      | 34          | 8.56   |
| Very much  | 5           | 1.26   |
| Total      | 396         | 100.00 |

## 4 Discussion

### 4.1 Comparison and interpretation

In this study, we applied and extended the DCE model to explore the influence of a set of attributes (BC, IE, IS, IQ, IN) toward consumers’ purchase propensity for pasta in Italy. As such, we estimated the preferences of respondents through MXL where attributes of the product were interacted with latent variables that proved significant interactions with respect to “behaviour” related to blockchain technology in food choice. Regarding the BC technology for pasta, our results are in line with Contò et al. (2016), who stated that when simulating a pasta buying process through CE, consumers seemed likely to choose products characterised by credibility attributes such as the origin of the wheat, for which they were also willing to pay a premium price. This certainly reflects that the application of a traceability system, through BC, on pasta would positively influence consumer purchasing behaviour, indicating that consumers are willing to pay a premium for the traceability of products. However, digital transformation process could stimulate the innovation in the agri-food sector too. In fact, the technology 4.0 can offer the agri-food companies to create new opportunities for success and gain competitive benefits. In addition, in this context, it is crucial consumer orientation as core competencies in dynamic

**TABLE 13** Respondents’ consent related to the transparency of operations along the pasta value chain (in number N and % of respondents).

| A greater transparency of operations along the pasta value chain offer:                                                                         | Level of consent  |      |          |      |                            |       |       |       |                |       |
|-------------------------------------------------------------------------------------------------------------------------------------------------|-------------------|------|----------|------|----------------------------|-------|-------|-------|----------------|-------|
|                                                                                                                                                 | Strongly disagree |      | Disagree |      | Neither agree nor disagree |       | Agree |       | Strongly agree |       |
|                                                                                                                                                 | N                 | %    | N        | %    | N                          | %     | N     | %     | N              | %     |
| A guarantee on the quality of the product                                                                                                       | 10                | 2.52 | 9        | 2.27 | 56                         | 14.11 | 207   | 52.14 | 115            | 28.97 |
| Social benefits (i.e., respect of the job contract, undeclared work, reduction of labour exploitation, etc.)                                    | 10                | 2.52 | 6        | 1.51 | 85                         | 21.41 | 217   | 54.66 | 79             | 19.90 |
| Environmental benefits (i.e., reduction of gas emissions, better efficiency in the use of water and energy, reduction of food waste, etc.)      | 4                 | 1.01 | 13       | 3.27 | 63                         | 15.87 | 206   | 51.89 | 111            | 27.96 |
| Benefits in terms of traceability of the production and food safety                                                                             | 8                 | 2.02 | 4        | 1.01 | 43                         | 10.83 | 225   | 56.68 | 117            | 29.47 |
| An increase of innovation in the agricultural sector (i.e., use of sensors IoT, GPS, drones, etc.), offering benefits in terms of food security | 6                 | 1.51 | 14       | 3.53 | 113                        | 28.46 | 193   | 48.61 | 71             | 17.88 |

TABLE 14 Psychographic latent variable composition.

| Latent | Items        | Weights | Standard deviation | Factor loadings |
|--------|--------------|---------|--------------------|-----------------|
| ATT    | A_Organic    | 0.322   | 0.687              | 0.702           |
|        | A_Origin     | 0.344   | 0.705              | 0.794           |
|        | A_Nutrition  | 0.293   | 0.664              | 0.676           |
|        | A_Label      | 0.290   | 0.623              | 0.669           |
| TRA    | T_Trace      | 0.346   | 0.797              | 0.627           |
|        | T_Social     | 0.362   | 0.829              | 0.656           |
|        | T_Innovation | 0.494   | 0.844              | 0.894           |

Source: our elaboration.

TABLE 15 Reliability measures.

| Latent | AVE   | Cronbach's $\alpha$ | Jöreskog's $\rho$ | Dijkstra-Henseler's $\rho$ |
|--------|-------|---------------------|-------------------|----------------------------|
| ATT    | 0.503 | 0.811               | 0.813             | 0.817                      |
| TRA    | 0.568 | 0.771               | 0.774             | 0.803                      |
| BLO    | 0.706 | 0.754               | 0.759             | 0.768                      |

Source: our elaboration. The latent variable "closeness to blockchain technology" (BLO) has been putted in relation with the following two latent variables "attention to credence attributes" (ATT) and "beliefs on traceability" (TRA), assuming that BLO is influenced by TRA and ATT while TRA is also influenced by ATT. Comparative fit index (CFI): 0.973; goodness of fit index (GFI): 0.967; root mean square error of approximation (RMSEA): 0.057; standardised root mean square residual (SRMR): 0.029.

market environments. Among others industry 4.0 technology, BC represents an innovative voluntary certification system that can improve efficiency, security, safety, and transparency even in food supply chains (Galvez et al., 2018). In addition, Chen et al. (2021) demonstrated that Chinese utility can benefit from both the application of blockchain technology and traditional traceability technologies, and consumers are more inclined to buy ecological agricultural products that use blockchain technology than those that use traditional traceability technologies. In this context, Bandinelli et al. (2023) also evaluated the consumers' interest in buying a package of ancient wheat pasta that includes all the information about its origin and processing methods. Their results highlighted the importance of the construct "perceived security," corresponding to "a threat that creates a circumstance, condition, or event with the potential to cause economic hardship in the form of destruction, disclosure, modification of data, fraud, waste, and abuse."

With respect to the safety and environmental sustainability of the pasta, these issues prevail for Italian consumers, reflecting their concern regarding the food safety information and the sustainable conditions of harvesting and processing, as well as antifraud issues related to pasta. This result is consistent with Altamore et al. (2019), who found that more than 90% of the sample wanted information on the healthiness of pasta or how it is produced, the origin of the raw material, and the absence of elements potentially harmful to human health, confirming the importance of labelling on purchasing choices. In addition, they found that health and origin are characteristics that consumers consider the most important in purchasing choices. Therefore, information and communication on the identity

characteristics of pasta seem to play an important role in building consumer awareness and thus influencing the purchase decision (Neuninger et al., 2017). In fact, more informed consumers are more likely to improve preferences for locally grown wheat and local pasta production. Moreover, since a traceability system can become a guarantee for the end user of the purchase of a sustainable product, the results produced by Defrancesco et al. (2017), which tested consumer preferences for the environmental attitudes of pasta, can be considered relevant for the research hypothesis presented. However, they found that, overall, consumers were not only unwilling to pay more for pasta products with beneficial environmental attributes and, to a lesser extent, health effects, but they firmly preferred traditional pasta. Similarly, Rossi et al. (2023) evaluated the WTP of Italian consumers for pasta from sustainable agriculture and the drivers that determine this WTP, but they arrived at more moderate results: Consumers recognised a higher WTP for sustainable pasta, but this value was influenced by drivers such as purchasing habits, personal characteristics, and environmental attitudes. In addition, our findings are consistent with Bandinelli et al. (2023), who reported that consumers are becoming more sceptical of the degree to which information reported on labels matches the actual product (Profeta et al., 2008; Sodano et al., 2008).

In addition, Wang and Scrimgeour (2023) determined that the product origin, quality control, food safety information, hygienic conditions, and scarcity management are the key features of blockchain food traceability that consumers considered to be crucial. Regarding the social sustainability information, our findings are more or less consistent with Nayal et al. (2023) and Kamilaris et al. (2019), who found that BC contributed to social sustainability, helping small farmers in insurance programmes, promoting smart contracts to protect labour from exploitation, and ensuring fairness in payments and taxation. However, our results are less consistent with Rana and Paul (2017), who found that consumers were willing to pay more for socially responsible products. In terms of innovation business, our results are less consistent with Basarir and Dayan (2022), who investigated on how innovative food products are perceived by consumers in United Arab Emirates, and how that perception affects their perceived risk and uncertainty, perceived cost/benefit, and attitude strengths toward the innovations. Moreover, Nazzaro et al. (2019) found that consumers were willing to pay higher price levels for the innovative product rather than for the traditional one. They also found a broad correlation between the innovative product attributes and the psychographic characteristics of consumers in two of the three consumer groups that were identified (i.e., rational adopters and pro-innovation), indicating the existence of many potential consumers. Moreover, as reported by Nazzaro et al. (2019), innovation in the agri-food sector is a tool for addressing the consumer-citizen's needs (Capitanio et al., 2012) and growing societal issues (Roucan-Kane et al., 2011). In fact it needs to be consider closely social and environmental changes too (Earle, 1997), contrary to the prevalent notion that innovation is primarily a technological process. For these reasons, academic and business attention in food innovations has increased, with a focus on the drivers that could guide consumer acceptance of innovation. In fact, for food firms to succeed in the food market, consumer perceptions of food innovations and their willingness to adopt or adapt them are crucial (Siegrist, 2008).

TABLE 16 Multinomial logit model, mixed logit model, and mixed logit model with interaction with psychographic terms.

| Variable                                               | MNL          |                | MXL                     |                | MXL with interactions |                |
|--------------------------------------------------------|--------------|----------------|-------------------------|----------------|-----------------------|----------------|
|                                                        | Coefficients | Standard Error | Coefficients            | Standard Error | Coefficients          | Standard Error |
| BC                                                     | 0.29465***   | 0.0628         | 0.43819***              | 0.12226        | 0.41831***            | 0.1152         |
| IE                                                     | 0.35557***   | 0.0585         | 0.59338***              | 0.09718        | 0.55040***            | 0.094          |
| IQ                                                     | 0.43043***   | 0.0636         | 0.78451***              | 0.11742        | 0.77677***            | 0.1164         |
| IS                                                     | 0.15692*     | 0.0801         | 0.28614**               | 0.13726        | 0.24272*              | 0.1358         |
| IN                                                     | 0.22692***   | 0.0632         | 0.32828***              | 0.11232        | 0.27616**             | 0.1087         |
|                                                        |              |                | (non-random parameters) |                |                       |                |
| OPTOUT                                                 | −1.56844***  | 0.1074         | −2.42456***             | 0.16347        | −2.41887***           | 0.1601         |
| PRICE                                                  | −0.38988***  | 0.0591         | −0.70929***             | 0.08829        | −0.66895***           | 0.0858         |
| Interaction terms                                      |              |                |                         |                |                       |                |
| BC: ATT                                                |              |                |                         |                | 0.11059               | 0.1146         |
| BC: TRA                                                |              |                |                         |                | 0.55770***            | 0.1177         |
| IE: ATT                                                |              |                |                         |                | 0.0579                | 0.0869         |
| IE:TRA                                                 |              |                |                         |                | 0.30539***            | 0.0877         |
| IQ: ATT                                                |              |                |                         |                | 0.06529               | 0.1063         |
| IQ: TRA                                                |              |                |                         |                | 0.31611***            | 0.1058         |
| IS: ATT                                                |              |                |                         |                | 0.29065***            | 0.1117         |
| IS: TRA                                                |              |                |                         |                | 0.11454               | 0.1078         |
| IN: ATT                                                |              |                |                         |                | 0.40513***            | 0.1018         |
| IN: TRA                                                |              |                |                         |                | 0.01848               | 0.0981         |
| Standard deviation                                     |              |                |                         |                |                       |                |
| SD_BC                                                  |              |                |                         |                | 1.64613***            | 0.1592         |
| SD_IE                                                  |              |                | 1.10565***              | 0.1131         | 1.04743***            | 0.1118         |
| SD_IQ                                                  |              |                | 1.47876***              | 0.1318         | 1.41667***            | 0.1361         |
| SD_IS                                                  |              |                | 1.17994***              | 0.1565         | 1.12018***            | 0.1564         |
| SD_IN                                                  |              |                | 1.23945***              | 0.1231         | 1.21040***            | 0.1274         |
| ***, **, and * ==>significance at 1, 5, and 10% level. |              |                |                         |                |                       |                |
| Log likelihood function                                | −2249.66     |                | −2065.7                 |                | −2017.87              |                |
| Inf.Cr.AIC                                             | 4513.3       |                | 4155.4                  |                | 4079.7                |                |
| AIC/N                                                  | 1.895        |                | 1.745                   |                | 1.713                 |                |
| K                                                      | 7            |                | 12                      |                | 22                    |                |

## 4.2 Implications, limitations, and future research

The obtained findings induce here public and private implications. In fact, this research contributes to the scientific literature by exploring new insights into Italian consumption in pasta preferences utility. Third, the current econometric exploration is primordial to set up market outreach strategies by pasta industrials that would meet Italian consumers' expectations and, consequently, enhance their financial performances. Fourth, examining consumers' attitudes and propensity toward the selected attributes has also public implications in terms of protecting and informing the consumer through clear and transparent

information, preventing the problem of agri-frauds, permitting to obtain continuous monitoring of the production processes to guarantee the sustainability and quality of the agri-food products such pasta, and providing added services to the consumers. However, the research does not verify spatial variability in consumers' preferences among Italian regions for the concerned pasta attributes. In this direction, we suggest an extension on examining Italian consumer needs regarding pasta in each region of the country through a face-to-face field social survey and including all species of pasta. In addition, we may allow for extending the research of the consumer segmentation between communities and different socio-demographic and psycho-variables classes.

TABLE 17 WTP calculation based on a Krinsky-Robb method with 500.

| Attribute | WTP        | Standard error |
|-----------|------------|----------------|
| BC        | 0.62533*** | 0.17432        |
| IE        | 0.82278*** | 0.14604        |
| IQ        | 1.16119*** | 0.18301        |
| IS        | 0.36284**  | 0.17611        |
| IN        | 0.41283*** | 0.14095        |

\*\*\*, \*\*, and \* ==>significance at 1, 5, and 10% level.

## 5 Conclusion

The analysis conducted revealed, among others, a particularly significant element with respect to the impact of BC on the pasta market. The consumer was willing to pay a price premium toward the guarantee of purchasing a safe product, in terms of the quality and safety, and that was traceable in relation to all the links in its value chain. Meanwhile, studies on consumer preferences and willingness to pay for blockchain technology in agri-food supply chain are limited, and academic research studies investigating supply chain of pasta are rare. In this context, our study aimed to fill this research gap regarding the WTP of consumers for food such as pasta traced through BC, encouraging consumers to make knowledgeable decisions and to take a proactive approach to achieving the goals of social and environmental sustainability as well as public health. In this direction, BC appears to support green practices contributing to achieve environmental targets and can give more benefits for the society. Italian consumers' preferences may push companies to achieve environmental sustainability and increase demands related to social issues by providing authentic product feedback. All these issues enhance consumers' environmental and social awareness and improve sustainable performance of the pasta supply chain. Moreover, BC pasta traceability system could overcome the problematic nature of traditional food traceability systems and will reduce the chances of food adulteration and frauds, ensuring that the information on products' labels is adherence. These capabilities can improve consumers' awareness in terms of assurance of quality, real-time tracking, safety along the food chain, healthy, and chain clarity. At the same time, BC can be used by stakeholders to promote consumer loyalty, enhance the product's reputation, and draw in new clients.

## Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

## Ethics statement

The data collected through the online questionnaire were used exclusively for statistical purposes and for this study. They will not be disclosed to third parties or used for private interests, own or

others, according to Regulation (EU) 2016/679 on the protection of individuals regarding the processing of personal data. The acquired information was exclusively used in an aggregate way, thus guaranteeing the most complete anonymity of the respondent. Furthermore, the consent from the participants was requested, at the beginning of the survey, to participate in this study in accordance with the national legislation and the institutional requirements.

## Author contributions

AP: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Software, Writing – original draft, Writing – review & editing, Visualization. MF: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Software, Writing – original draft, Writing – review & editing, Visualization. VF: Conceptualization, Supervision, Validation, Writing – review & editing. ET: Data curation, Writing – original draft. AC: Data curation, Writing – original draft. FB: Conceptualization, Funding acquisition, Project administration, Writing – review & editing.

## Funding

The author(s) declare financial support was received for the research, authorship, and/or publication of this article. This study was carried out within the Agritech National Research Center and received funding from the European Union Next-Generation EU (Piano nazionale di ripresa e resilienza (pnrr)-missione 4 componente 2, investimento 1. 4-d.d. 1032 17/06/2022, cn00000022). This manuscript reflects only the authors' views and opinions, neither the European Union nor the European Commission can be considered responsible for them.

## Acknowledgments

The authors would like to thank Enza Campanella and Daniela Cuppone for their administrative support.

## Conflict of interest

MF was employed by Sinagri S.r.l.

The remaining authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

## Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

# References

- Ali, B. M., Ang, F., and van der Fels-Klerx, H. J. (2021). Consumer willingness to pay for plant-based foods produced using microbial applications to replace synthetic chemical inputs. *PLoS One* 16:e0260488. doi: 10.1371/journal.pone.0260488
- Altamore, L., Bacarella, S., Columba, P., Chironi, S., and Ingrassia, M. (2017). The Italian consumers' preferences for pasta: does environment matter? *Chem. Eng. Trans.* 58, 859–864. doi: 10.3303/CET1758144
- Altamore, L., Ingrassia, M., Columba, P., Chironi, S., and Bacarella, S. (2019). Italian consumer preferences for pasta and consumption trends: tradition or innovation? *J. Int. Food Agribus. Mark.* 32, 1–24. doi: 10.1080/08974438.2019.1650865
- Bandinelli, R., Scozzafava, G., Bindi, B., and Fani, V. (2023). Blockchain and consumer behaviour: results of a technology acceptance model in the ancient wheat sector. *CLSCN* 8:100117. doi: 10.1016/j.clscn.2023.100117
- Basarir, A., and Dayan, M. (2022). The consumer's perceptions and attitudes toward innovative foods in United Arab Emirates. *EJFA* 34:6. doi: 10.9755/ejfa.2022.v34.i6.2895
- Bucher, T., Van der Horst, K., and Siegrist, M. (2011). Improvement of meal composition by vegetable variety. *Public Health Nutr.* 14, 1357–1363. doi: 10.1017/S136898001100067X
- Capitanio, F., Coppola, A., and Pascucci, S. (2012). Product and process innovation in the Italian food industry. *Agribusiness* 26, 503–518. doi: 10.1002/agr.20239
- Castellini, G., Lucini, L., Rocchetti, G., Lorenzo, J. M., and Graffigna, G. (2022). Determinants of consumer acceptance of new technologies used to trace and certify sustainable food products: a mini-review on blockchain technology. *Curr Opin Environ Sci Health* 30:100403. doi: 10.1016/j.coesh.2022.100403
- Cavallo, C., Del Giudice, T., Cicia, G., Di Monaco, R., and Caracciolo, F. (2014). Revealed preference approach for analysing consumer preferences: a choice experiment with a real-life setting. *Int. Agric. Policy Edizioni L'Informatore Agrario* 2014, 44–50. doi: 10.22004/ag.econ.329127
- Chen, X., Shang, J., Zada, M., Zada, S., Ji, X., Han, H., et al. (2021). Health is wealth: study on consumer preferences and the willingness to pay for ecological agricultural product traceability technology: evidence from Jiangxi Province China. *Int. J. Environ. Res. Public Health* 18:11761. doi: 10.3390/ijerph182211761
- Contò, F., Antonazzo, A. P., Conte, A., and Cafarelli, B. (2016). Consumers' perception of traditional sustainable food: an exploratory study on pasta produced with ancient native varieties of durum wheat. *J. Agric. Econ.* 71, 325–337. doi: 10.13128/REA-18651
- Dahlhausen, J. L., Rungie, C., and Roosen, J. (2018). Value of labeling credence attributes-common structures and individual preferences. *Agric. Econ.* 49, 741–751. doi: 10.1111/agec.12456
- Defrancesco, E., Perito, M. A., Bozzolan, I., Cei, L., and Stefani, G. (2017). Testing consumers' preferences for environmental attributes of pasta. Insights from an ABR Approach. *Sustainability* 9:1701. doi: 10.3390/su9101701
- Earle, M. D. (1997). Innovation in the food industry. *Trends Food Sci. Technol.* 8, 166–175. doi: 10.1016/S0924-2244(97)01026-1
- Fiore, M., Frem, M., Mongiello, M., Bozzo, F., Montemurro, C., Tricarico, G., et al. (2024). Blockchain-based food traceability in Apulian marketplace: improving sustainable Agri-food consumers perception and trust. *Internet Technol. Lett.* e503, 1–6. doi: 10.1002/itl2.503
- Fiore, M., Mongiello, M., and Tricarico, G. (2023). "Blockchain-based food traceability system for Apulian marketplace: enhancing transparency and accountability in the food supply chain" in *35th international conference on software engineering and knowledge engineering (SEKE)* (IEEE), Ed. Wiley-Blackwell. New Jersey, USA: Hoboken. 1–4.
- Foschia, M., Peressini, D., Sensidoni, A., Brennan, M. A., and Brennan, C. S. (2014). Mastication or mastication: does the preparation of sample affect the predictive in vitro glycemic response of pasta? *Star* 66, 1096–1102. doi: 10.1002/star.201300156
- Friedel, J. E., Foreman, A. M., and Wirth, O. (2022). An introduction to "discrete choice experiments" for behavior analysts. *Behav. Process.* 198:104628. doi: 10.1016/j.beproc.2022.104628
- Galvez, J. F., Mejuto, J. C., and Simal-Gandara, J. (2018). Future challenges on the use of blockchain for food traceability analysis. *Trends Anal. Chem.* 107, 222–232. doi: 10.1016/j.TRAC.2018.08.011
- Hess, S., Hensher, D., and Daly, A. J. (2012). Not bored yet – revisiting respondent fatigue in stated choice experiments. *Trans. Res. Part A Policy Pract.* 46, 626–644. doi: 10.1016/j.tra.2011.11.008
- Istituto Nazionale di Statistica – ISTAT (2023). Italian population in 2022. Available at: <https://dati.istat.it/> (Accessed May 5, 2023).
- Jürkenbeck, K. (2023). Consumer trust in organic food producers and its influence on consumers' attitudes toward food reformulation and its sensory consequences. *Food Human.* 1, 793–799. doi: 10.1016/j.foohum.2023.07.031
- Kamilaris, A., Fonts, A., and Prenafeta-Boldó, F. X. (2019). The rise of blockchain technology in agriculture and food supply chains. *Trends Food Sci. Technol.* 91, 640–652. doi: 10.1016/j.tifs.2019.07.034
- Lin, X., Chang, S.-C., Chou, T.-H., Chen, S.-C., and Ruangkanjanases, A. (2021). Consumers' intention to adopt Blockchain food traceability technology towards organic food products. *Int. J. Environ. Res. Public Health* 18:912. doi: 10.3390/ijerph18030912
- McFadden, D. (1974). "Conditional logit analysis of qualitative choice behavior" in *Frontiers in econometrics*. ed. P. Zarembka (New York: Academic Press)
- Nayal, K., Raut, R. D., Narkhede, B. E., Priyadarshinee, P., and Panchal, G. B. (2023). Antecedents for blockchain technology-enabled sustainable agriculture supply chain. *Ann. Oper. Res.* 327, 293–337. doi: 10.1007/s10479-021-04423-3
- Nazzaro, C., Lerro, M., Stanco, M., and Marotta, G. (2019). Do consumers like food product innovation? An analysis of willingness to pay for innovative food attributes. *Br. Food J.* 121, 1413–1427. doi: 10.1108/BFJ-06-2018-0389
- Neuninger, R., Mather, D., and Duncan, T. (2017). Consumer's scepticism of wine awards: a study of consumers' use of wine awards. *J. Retail. Consum. Serv.* 35, 98–105. doi: 10.1016/j.jretconser.2016.12.003
- Palmieri, N., Stefanoni, W., Latterini, F., and Pari, L. (2021). An Italian explorative study of willingness to pay for a new functional pasta featuring *Opuntia ficus indica*. *Agriculture* 11:701. doi: 10.3390/agriculture11080701
- Pappalardo, G., Chinnici, G., and Pecorino, B. (2017). Assessing the economic feasibility of high heat treatment, using evidence obtained from pasta factories in Sicily (Italy). *J. Clean. Prod.* 142, 2435–2445. doi: 10.1016/j.jclepro.2016.11.032
- Pasdar, Y., Darbandi, M., Azandaryani, H., and Hooshmand, A. S. (2017). Macronutrients compliance between foods labels and marketing package content values. *ATMPH* 10, 999–1003. doi: 10.4103/ATMPH.ATMPH\_309\_17
- Petrontino, A., Frem, M., Fucilli, V., Labbate, A., Tria, E., and Bozzo, F. (2023a). Ready-to-eat innovative legumes snack: the influence of nutritional ingredients and labelling claims in Italian consumers' choice and willingness-to-pay. *Nutrients* 15:1799. doi: 10.3390/nu15071799
- Petrontino, A., Frem, M., Fucilli, V., Tricarico, G., and Bozzo, F. (2022). Health-nutrients and origin awareness: implications for regional wine market-segmentation strategies using a latent analysis. *Nutrients* 14:1385. doi: 10.3390/nu14071385
- Petrontino, A., Madau, F., Frem, M., Fucilli, V., Bianchi, R., Campobasso, A. A., et al. (2023b). Seafood choice and consumption behavior: assessing the willingness to pay for an edible sea urchin. *Food Secur.* 12:418. doi: 10.3390/foods12020418
- Pounis, G., Castelnovo, A., and Costanzo, S. (2016). Association of pasta consumption with body mass index and waist-to-hip ratio: results from Moli-sani and INHES studies. *Nutr. Diabetes* 6:e218. doi: 10.1038/ntud.2016.20
- Predieri, S., Sotis, G., Rodinò, P., Gatti, E., Magli, M., Rossi, F., et al. (2018). Older adults' involvement in developing satisfactory pasta sauces with healthy ingredients. *Br. Food J.* 120, 804–814. doi: 10.1108/BFJ-06-2017-0358
- Profeta, A., Enneking, U., and Balling, R. (2008). Interactions between brands and CO labels: the case of "Bavarian beer" and "Munich beer" – application of a conditional logit model. *J. Int. Food Agribus. Mark.* 20, 73–89. doi: 10.1080/08974430802157655
- Qian, J., Garcia, L. R., Fan, B., Villalba, J. I. R., McCarthy, U., Zhang, B., et al. (2020). Food traceability system from governmental, corporate, and consumer perspectives in the European Union and China: a comparative review. *Trends Food Sci. Technol.* 99, 402–412. doi: 10.1016/j.tifs.2020.03.025
- Rana, J., and Paul, J. (2017). Consumer behavior and purchase intention for organic food: a review and research agenda. *J. Retail. Consum. Serv.* 38, 157–165. doi: 10.1016/j.jretconser.2017.06.004
- Rossi, E. S., Zabala, J. A., Caracciolo, F., and Blasi, E. (2023). The value of crop diversification: understanding the factors influencing consumers' WTP for pasta from sustainable agriculture. *Agriculture* 13:585. doi: 10.3390/agriculture13030585
- Roucan-Kane, M., Gray, A. W., and Boehlje, M. D. (2011). Approaches for selecting product innovation projects in U.S. food and agribusiness companies. *Int. Food Agribus. Manag. Rev.* 14, 51–68. doi: 10.22004/ag.econ.117599
- Rungie, C. M., Coote, L. V., and Louviere, J. J. (2012). Latent variables in discrete choice experiments. *J. Choice Model.* 5, 145–156. doi: 10.1016/j.jocm.2013.03.002
- Siegrist, M. (2008). Factors influencing public acceptance of innovative food technologies and products. *Trends Food Sci. Technol.* 19, 603–608. doi: 10.1016/j.tifs.2008.01.017
- Sodano, V., Hingley, M., and Lindgreen, A. (2008). The usefulness of social capital in assessing the welfare effects of private and third-party certification food safety policy standards: trust and networks. *Br. Food J.* 110, 493–513. doi: 10.1108/00070700810868988
- Spence, M., Stancu, V., Elliott, C. T., and Dean, M. (2018). Exploring consumer purchase intentions towards traceable minced beef and beef steak using the theory of planned behavior. *Food Control* 91, 138–147. doi: 10.1016/j.foodcont.2018.03.035
- Stasi, A., and Bairo, A. (2023). A pre-competitive research on frozen gnocchi: quality evaluation and market survey. *Ital J Food Sci.* 35, 98–114. doi: 10.15586/ijfs.v35i2.2269
- Statista (2023). Leading suppliers of Italy's imports of pasta in 2022. Available at: <http://www.statista.com/topics/10934/pasta-market-in-italy/#topicOverview/> (Accessed November 7, 2023).

- Survey Monkey (2023). Available at: <https://www.surveymonkey.com/mp/sample-size-calculator/> (Accessed May 9, 2023).
- Tonsor, G. T., and Shupp, R. S. (2011). Cheap talk scripts and online choice experiments: “looking beyond the mean”. *Am. J. Agric. Econ.* 93, 1015–1031. doi: 10.1093/ajae/aar036
- Van der Stricht, H., Prophet, A., Hung, Y., and Verbeke, W. (2023). Consumers’ willingness to buy microalgae protein pasta: which label can drive sales? *Food Qual. Saf.* 110:104948. doi: 10.1016/j.foodqual.2023.104948
- Van Loo, E. J., Caputo, V., Nayga, R. M., Meullenet, J.-F., and Ricke, S. C. (2011). Consumers’ willingness to pay for organic chicken breast: evidence from choice experiment. *Food Qual. Prefer.* 22, 603–613. doi: 10.1016/j.foodqual.2011.02.003
- Wang, O., and Scrimgeour, F. (2023). Consumer adoption of blockchain food traceability: effects of innovation-adoption characteristics, expertise in food traceability and blockchain technology, and segmentation. *Br. Food J.* 125, 2493–2513. doi: 10.1108/BFJ-06-2022-0466
- Yeh, J. -Y., Liao, S. -C., Wang, Y. -T., and Chen, Y. -J. (2019). *Understanding consumer purchase intention in a Blockchain Technology for Food Traceability and Transparency context*. IEEE Social Implications of Technology (SIT), and Information Management (SITIM), Matsuyama, Japan.

**CHAPTER 3: Ornamental Plants Perception and Sustainable Nurseries**  
(Published in *Horticulturae*)



## Article

# Consumers' Perceptions for an Outdoor Ornamental Plant: Exploring the Influence of Novel Plant Diseases Diagnostics and Sustainable Nurseries Cultivation Management

Michel Frem <sup>1</sup>, Alessandro Petrontino <sup>2,\*</sup>, Vincenzo Fucilli <sup>2</sup>, Barbara De Lucia <sup>2</sup>, Emanuela Tria <sup>2</sup>, Adele Annarita Campobasso <sup>2</sup>, Federica Calderoni <sup>2</sup> and Francesco Bozzo <sup>2</sup>

<sup>1</sup> Sinagri s.r.l., Spin Off of the University of Bari-Aldo Moro, Via Amendola 165/A, 70126 Bari, Italy; mefrem@sinagrispinoff.it

<sup>2</sup> Department of Soil, Plant and Food Sciences, University of Bari Aldo Moro, Via Amendola 165/A, 70126 Bari, Italy; vincenzo.fucilli@uniba.it (V.F.); barbara.delucia@uniba.it (B.D.L.); emanuela.tria@uniba.it (E.T.); adele.campobasso@uniba.it (A.A.C.); federica.calderoni@uniba.it (F.C.); francesco.bozzo@uniba.it (F.B.)

\* Correspondence: alessandro.petrontino@uniba.it

**Abstract:** A discrete choice experiment was conducted to assess the perceptions and willingness-to-pay of Italian consumers regarding plant diagnosis and sustainable cultivation attributes in outdoor ornamental plants, specifically *Abelia × grandiflora*. The results revealed that most Italian consumers place great importance on the health of ornamental plants during the purchasing process, with a preference for obtaining them from nursery facilities. Additionally, they demonstrated a willingness to pay a price premium for innovative plant diagnosis and sustainable cultivation in the production of *A. × grandiflora*, amounting to EUR 1.10 and EUR 0.90, respectively. These findings have significant implications for (i) nursery growers, enabling them to shape their sustainable nursery management and marketing strategies, and (ii) policymakers, facilitating the enhancement of communication strategies and the implementation of awareness campaigns aimed at promoting the sale of healthy Italian ornamental species, following the current EU regulation 2020/1201.

**Keywords:** choice experiment; consumer behavior; innovation; outdoor ornamental plant; quarantine pests; plant marketing; sustainable nurseries cultivation management; *Xylella fastidiosa*



**Citation:** Frem, M.; Petrontino, A.; Fucilli, V.; De Lucia, B.; Tria, E.; Campobasso, A.A.; Calderoni, F.; Bozzo, F. Consumers' Perceptions for an Outdoor Ornamental Plant: Exploring the Influence of Novel Plant Diseases Diagnostics and Sustainable Nurseries Cultivation Management. *Horticulturae* **2024**, *10*, 501. <https://doi.org/10.3390/horticulturae10050501>

Academic Editor: Christian Fischer

Received: 5 April 2024

Revised: 6 May 2024

Accepted: 11 May 2024

Published: 13 May 2024



**Copyright:** © 2024 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

## 1. Introduction

### 1.1. Background and Justification

Plant diagnosis (PD) is a scientific process that involves detecting, identifying, and distinguishing the presence or absence of biotic stresses such as bacteria, viruses, fungi, nematodes, insects, arachnids, and weeds, at various levels of classification, including genus, species, and strain [1]. A specific focus within PD has been the detection of *Xylella fastidiosa* (L.), (Xf hereafter), an invasive polyphagous bacterium that affects approximately 655 plant species [2]. This study expands on previous research in plant pathology, which underscored the significant effects of diseases such as *Xylella fastidiosa* (L.) on ornamental plants, stressing the importance of reliable diagnostic methods [3–5]. Xf has had a significant impact on the Salento area in the Apulia region of southern Italy, causing severe economic, social, and ecological damage [1,6]. As a result, the plant nursery industry in Apulia has experienced negative consequences in terms of productivity and profitability, due to export restrictions on live plants, trees, edible fruits and nuts, shrubs, bushes, and ornamental species from areas affected by Xf [6]. Import controls and inspections have become mandatory in Europe for plants intended for planting and for nurseries in demarcated areas [7]. The introduction of infected plants for planting, primarily from America, is the main driver of Xf introduction into new countries, and the presence of xylem-feeding

insect vectors (such as *Philaeus spumarius* and *Neophilaenus campestris*, acting as the primary and secondary Xf vectors in Apulia, respectively) contributes to the local transmission and spread of this harmful bacterium [8]. Consequently, the adoption and implementation of novel plant diagnosis assays, utilizing serological and molecular tests [7], have been crucial for confirming the absence of pathogenic organisms like Xf in potted ornamental species, which is essential for regulatory decisions, reestablishment of pest-free areas, trade purposes, effectiveness of pest eradication strategies, pest risk analysis, and addressing consumer concerns.

In addition to plant diagnosis, sustainable cultivation techniques (SCT) are seen as essential management tools to improve the quality, productivity, competitiveness, and commercialization of ornamental plants, while also reducing the environmental impact of cultivation processes [9]. Producers, including ornamental firms, increasingly utilize sustainable production methods, green claims, and eco-labeling to align with consumer concerns and gain a competitive advantage [10]. Responsible consumption, consumer preferences, and lifestyles also play a role in influencing producers, such as plant nursery entrepreneurs, to adopt less environmentally harmful inputs and production methods [11]. SCTs encourage nursery growers to prioritize eco-friendly management practices and cost-effective resource and input usages, including water, electricity, land, growing media, pots, pesticides, fertilizers, and labor, thereby contributing to a more sustainable plant production system, and potentially benefiting the Italian nursery sector. In ornamental cutting propagation, the utilization of biostimulants (i.e., seaweed extracts, as an alternative to synthetic auxins) to improve adventitious roots formation and promote balanced shoots aligns with the principles of sustainability and eco-friendly production [12,13]. However, understanding consumers' willingness-to-pay (WTP) for SCTs is crucial to achieve this goal.

## 1.2. Literature Review

The most recent literature exploring innovation in technologies for plant diagnostics and sustainable cultivation techniques provided a contemporary framework for our analysis.

In terms of plant diagnostics, Ali et al. [14] provided valuable insights into the use of biosensors (i.e., isothermal amplification, nanomaterials, robotics, lab-on-a-chip devices) as effective emerging tools for early detection of plant pathogens in agriculture, while the conventional laboratory-based methods are costly, time-consuming, and require specialized skills. In addition, Dheeraj et al. [15] proposed a novel appropriate technique in their study (i.e., a lightweight dense net model, LWDN), based on the Dense Net 121 architecture, for real-time plant diagnosis on portable and mobile devices with limited computational resources, contributing to sustainable agriculture and food security. In their paper, Sharma et al. [16] proposed also a new smart plant leaf disease detection technique (i.e., a deeper lightweight convolutional neural network architecture, DLMC-Net) for several crops for real-time agricultural use on simple leaf images of both healthy and diseased plants, contributing to effective disease management in agriculture. In addition, Fan et al. [17] suggested a leaf image-based disease recognition tool in their research, using transfer learning and feature fusion, advancing the fight against agricultural biotic threats and ensuring healthier crops. Moreover, Dhaka et al. [18], in their review, provided valuable insights into the integration of Internet of things (IoT) and deep learning models as powerful tools for addressing the automatic detection, visualization, and classification of plant diseases. In their review, Jafar et al. [19] delved into the critical role of accurate and rapid plant disease detection, such as the combination of artificial intelligence (AI) with IoT platforms such as smart drones for field-based disease detection and monitoring, enhancing long-term agricultural yields. Furthermore, Devi et al. [20] reviewed the common detection techniques of plant viruses (i.e., ELISA, Western blot, dot blot, immuno-fluorescent assay) and stressed the considerable progress made in microarray and next-generation sequencing detection of plant diseases, like LAMP (loop mediated isothermal amplification), RPA (recombinase polymerase amplification) and HAD (helicase-dependent amplification), con-

tributing to enhance productivity, improving crop quality, reducing production costs, and mitigating the environmental impact of chemicals in agriculture.

With respect to the use of sustainable cultivation practices, Fuentes-Peñailillo et al. [21] highlighted the groundbreaking potential of next-generation technologies in soilless plant production (i.e., AI monitoring systems that offer accuracy in tracking critical variables like nutrient concentrations and pH levels) and precision farming methods, enhancing precision of resource allocation and farm management. In addition, Li et al. [22] also stressed the considerable potential of soilless cultural systems that maximize the benefits of the greenhouse horticulture environment, enhancing the growth of crops. Moreover, Bantis et al. [23] evidenced the importance of grafting, an eco-friendly technique based on high-quality grafted seedlings, in offering transformative benefits for growers. Furthermore, Huang and Gu [24] also explored the promising use of biochar in optimizing the plant growth in horticulture crop production systems, when used in container substrates. Moreover, Cardoso et al. [25], in their special issue overview, highlighted (i) the relevance of advanced breeding and genetic improvement techniques that lead to better plant ornamental varieties; (ii) the importance of automation, robotics, and precision agriculture that enhance ornamental plant production efficiency; and (iii) the consideration of the biotechnology that allows for genetic modification and improved traits of ornamental plant cultivars. Finally, Daras [26], in his critical review, underscored the importance of cultivating native and specialty ornamental plants to offer eco-friendly alternatives, meeting future consumer needs, while implementing sustainable practices.

Concerning consumer behavior, numerous papers have examined consumer preferences for ornamental plants [27–30]. While many studies focused on various attributes influencing purchasing decisions, only a limited number specifically investigated the significance of aesthetic aspects and physical factors, local production, and eco-friendly cultivation techniques, such as seedling substrates and prices [31]. For example, Wagstaffe et al. [32] examined the impact of intensive cultural practices on the flowering performance of the herbaceous perennial *Coreopsis grandiflora* cv. Flying Saucers, exploring how these practices influenced customers' motivations to purchase and plant the species in their gardens. Palma et al. [33] found that price was the most influential factor in the purchasing decisions of Hawaiian consumers, while color had the least impact on their choice of orchids, using a conjoint analysis approach. Rhin et al. [34] investigated consumer preferences for organic production methods and origin promotions in ornamental species, employing eye-tracking experiments to study visual attention and its influence on decisions regarding indoor foliage and fruit-producing plants. Furthermore, Hovhannisyan and Khachatryan [30] analyzed the influence of socio-economic and demographic factors on the demand for ornamental plants using a theory-based demand model. However, few studies have addressed the factors that impact Italian consumers' preferences or estimated their WTP for specific attributes and types of ornamental species. In this regard, Schimmenti et al. [10] explored the behavior of Italian consumers in relation to conventional and organic flowers and ornamental plants, employing a behaviorist approach based on an econometric probit model.

### 1.3. Aims and Research Questions

Within the framework of the Apulian region funded project “ProDiQuaVi” (transfer of protocols for quarantine and harmful organisms and for the selection of sanitary materials improved for the Apulian nursery) ([www.prodiquavi.it](http://www.prodiquavi.it), accessed on 14 April 2021), we conducted a preliminary investigation to examine whether potted ornamental plants, diagnosed and produced through a sustainable cultivation cycle, could command a price premium compared to those without phytosanitary diagnostics and conventional cultivation techniques. Our study focused on *Abelia* × *grandiflora*, created by crossing the wild species *A. chinensis* and *A. uniflora* (*Caprifoliaceae* family), as a case study of an open field grown shrub, due to it being in the top 10 marketed potted species, its evergreen status as a potential feeding plant for Xf vectors, and its economic significance for Italian nursery en-

trepreneurs. In this direction, this paper addressed three interconnected aspects: (i) Italian consumers' behavior and propensity towards ornamental plants, (ii) their WTP for labelling information regarding potted plant diagnosis and cultivation techniques, and (iii) how their demographic and socio-economic characteristics interact with potted ornamental plant prices.

## 2. Methodology

Consumers' perceptions towards goods and services are commonly assessed through two categories of economic methods: (i) revealed preference methods (such as market price, cost-based, hedonic pricing, and travel cost), and (ii) stated preference techniques (such as conjoint analysis, CA and DCE). On the one hand, the first category is based on observed consumer attitudes and behavior. On the contrary, the second category assumes a hypothetical situation for consumers to assess their preferences and estimate their WTP. Among these, we opted in this study for the second group of econometric methods, and we mainly considered the DCE, due to its (i) best alignment with and suitability for our hypothetical research objectives; (ii) precision for assessing numerous attributes in which respondents make choices on trade-offs, similarly to how they would decide in actual purchase situations; (iii) great flexibility in attribute design, in which we could include both continuous and categorical attributes, and respondents can choose from various combinations, while the CA method is limited by the flexibility of attribute combinations, as supported by the recent papers of Čop et al. [35], Johansson et al. [36], and Wang et al. [37] as well as Johnston [38]. In addition, the CA has evolved from only two possibilities (i.e., status quo/no-buy and one hypothetical option), with which it is difficult to fully capture the consumer decision making process, while within the DCE approach, consumers have the possibility to choose among two, three, or more hypothetical alternatives, as described below, providing more valuable evidence on consumers preferences and inclinations, and addressing a complex decision-making process. In the following sections, we describe the adopted DCE methodology, which consists of four main steps: (i) determination of attributes and levels, (ii) experimental design and choice set, (iii) social survey, and (iv) econometric models and data interpretation using a multinomial logit model (MNL), random parameters (mixed) logit model (RPL), and a latent class model (LCM).

### 2.1. Selection of the Attributes and Their Levels

We selected three attributes (Table 1) in alignment with the innovative and sustainability goals of the "ProDiQuaVi" project, with input from a focus group consisting of Italian horticulture experts. The first attribute comprised two levels. The first level is a binary attribute (0, 1), where (1) represents the utilization of a novel plant phytosanitary diagnostic protocol, such as mass RNA sequencing [7] for the rapid detection of quarantine harmful organisms like Xf in plants intended for vegetative propagation. This level offered advantages such as lower costs and shorter detection times. Baseline, on the other hand, denoted the absence of any plant phytosanitary diagnosis in nurseries. The second level is also a binary (0, 1) attribute related to potted plant cultivation methods in nurseries, where (1) referred to a sustainable cultivation technique that included benefits such as a shortened rooting period (−20 days), reduced cutting mortality rate (−20%), and the efficient use of resources and inputs, as outlined in Table 2. The last attribute was the price of potted plants, with of four levels reflecting market ranges taken from a market analysis through Italian sellers. The four levels reflect the upper and lower ranges of the current average nursery selling price for *A. × grandiflora* with a diameter of 16 cm.

**Table 1.** *A. × grandiflora* attributes and attribute levels used in this choice experiment.

| Attribute<br>(Code)                                     | Level Number | Level                                                                                                                                                    |
|---------------------------------------------------------|--------------|----------------------------------------------------------------------------------------------------------------------------------------------------------|
| Phytosanitary diagnosis in nursery<br>(Code: diagnosis) | 2            | (1) Presence (use) of a novel plant phytosanitary diagnostic protocol with low costs and times<br>(2) Absence (non-use) of plant phytosanitary diagnosis |
| Nursery cultivation technique<br>(Code: technique)      | 2            | (1) Sustainable cultivation technique<br>(2) Conventional cultivation technique                                                                          |
| Price (Code: price)                                     | 4            | (1) EUR 2.00;<br>(2) EUR 4.00;<br>(3) EUR 6.00;<br>(4) EUR 10.00                                                                                         |

**Table 2.** Comparison between conventional and sustainable *A. × grandiflora* cultivation techniques used in the choice experiment.

| Input or Resource for the <i>Abelia grandiflora</i> Cultivation Process | Conventional Cultivation Technique                                                                                                                                       | Sustainable Cultivation Technique                                                                                                                                                                                                                                    |
|-------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Stock mother plants and cuttings                                        | Use of pot-bred mother plants from previous production cycles carried out at the same nursery level and may not guarantee healthy potted plants                          | Use of certified planting material from accredited organisms that may guarantee healthy potted plants                                                                                                                                                                |
| Rooting promoters and cutting propagation                               | Use of chemical plant growth regulator (as a source of auxin only—rooting powder hormone—IBA at a concentration of 0.5% <i>w/w</i> )<br>Massive use of biocontrol fungus | Use of a bio root stimulator and balanced shoots (as a natural source of auxins, cytokinin, polysaccharides, and vitamins)<br>Use of brown seaweed-extract-based biostimulants (at a concentration of 1 mL L <sup>−1</sup> )<br>Low application of biocontrol fungus |
| Labor                                                                   | Requires increased working hours during the production cycle                                                                                                             | Requires few working hours during the production cycle                                                                                                                                                                                                               |
| Chemical treatment                                                      | Massive use of chemical fungicides                                                                                                                                       | Low application of chemical fungicides                                                                                                                                                                                                                               |
| Consumables (pots)                                                      | Requires more pots due to a potentially high mortality rate                                                                                                              | Requires fewer pots due to a potentially lower mortality rate                                                                                                                                                                                                        |
| Consumables (water, fuel)                                               | Requires greater fuel and water resources due to a relatively high production cycle duration                                                                             | Requires fewer fuel and water resources due to a relatively low production cycle duration                                                                                                                                                                            |
| Whole production cycle duration in days                                 | 280 days due to more days for the rooting phase owing to the use of a relative low concentration of bio root stimulators                                                 | 260 days due to less days for the rooting phase, owing to the use of a relatively high concentration of bio root stimulators                                                                                                                                         |

Source: Based on Frem et al. [39] and Loconsole et al. [13].

## 2.2. Experimental Design and Choice Set

The selected attributes and their corresponding levels (Table 1) resulted in a full factorial design of 120 alternative scenarios, which posed operational constraints. To overcome these constraints and the optimize data collection, we employed a D-efficient Bayesian design [40,41] based on a full factorial design obtained with Equation (1), using the AlgDesign package in R software (R-4.4.0). This approach allowed us to improve the data quality, reduce costs and time requirements, and obtain more precise information from the entire population sample participating in the choice experiment [42,43]. By reducing

the D-error [44], we ensured a more accurate estimation of consumer preferences. As a result, we generated 16 distinct profiles, representing choice sets, organized in a single block consisting of 8 choice sets. The order of options within each choice set was randomized [45] and supported by visual images, pictograms, and verbal descriptions of the attributes of concern [46,47]. These choice sets were specifically designed for *Abelia grandiflora* plants with a diameter of  $\varnothing 16$  cm. Each choice set presented two options (Option A and Option B), as well as an additional Option C, which allowed respondents to choose neither option A nor option B (referred to as “no-buy” or “no choice”), as depicted in Table 3.

$$N = \frac{J_n (J_n - 1)}{2} \quad (1)$$

where N is the number of possible combinations of alternatives,  $J_n$  corresponds to  $2^2 * 4^1$ , whereby 2 attributes (e.g., “diagnosis” and “technique”) had 2 levels and 1 attribute (“price”) presented 4 levels, as illustrated in Table 1.

**Table 3.** Example of a choice set used in this choice experiment.

|                                                                                                                                                                                                                                                                                                                                                                                         |                                                    |                                                                                                                                                                                                                                                                                                                                                                                                            |                                                        |                                                                                                                       |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------|
| <div><div></div><div><div>Tecniche sostenibili di coltivazione</div></div><div><div>Nessuna diagnosi fitosanitaria</div></div></div> |                                                    | <div><div></div><div><div>Tecniche convenzionali di coltivazione</div></div><div><div>Diagnosi fitosanitaria con tecniche innovative</div></div></div> |                                                        | <div><div>Non acquisto</div></div> |
| Sustainable cultivation technique                                                                                                                                                                                                                                                                                                                                                       | Absence (non-use) of plant phytosanitary diagnosis | Conventional cultivation technique                                                                                                                                                                                                                                                                                                                                                                         | Use of a novel plant phytosanitary diagnostic protocol | No-Buy                                                                                                                |
| I opt for:                                                                                                                                                                                                                                                                                                                                                                              | <input type="checkbox"/> Option A                  | <input type="checkbox"/> Option B                                                                                                                                                                                                                                                                                                                                                                          | <input type="checkbox"/> Option C                      |                                                                                                                       |

### 2.3. Sampling and Social Survey

We initially calculated a target representative sample size (n) of 385 Italian respondents according to the common Equation (2) for sampling. Then, we conducted an online social survey using a questionnaire (Supplementary Material File—Questionnaire S1) from June 2021 to June 2022, from which we obtained 520 questionnaires. Finally, we retained for our econometric analysis 464 valid and complete responses, representing an increase of 20% over the target number of respondents that needed to be initially included in our analysis.

$$n = \frac{\frac{z^2 * p(1-p)}{e^2}}{1 + \left( \frac{z^2 * p(1-p)}{e^2 * N} \right)} \quad (2) = \frac{\frac{1.96^2 * 0.5(1-0.5)}{(0.05)^2}}{1 + \left( \frac{1.96^2 * 0.5(1-0.5)}{(0.05)^2 * 50,208,329} \right)} = 385 \text{ respondents at least}$$

where n is the sample size. N is the Italian population size over 18 years old ( $N = 50,208,329$  in the 1st of January 2021 based on ISTAT [48]). e: is the margin of error (percentage in decimal form: 5%). z: is the z-score ( $z = 1.96$  for a desired confidence level of 95%). p: is the standard deviation ( $p = 0.5$ )

The questionnaire was divided into three sections (Supplementary Material File—Questionnaire S1). The first section included questions about the respondent’s habits and propensity to purchase ornamental plants. In the second section, each respondent was presented with eight purchase simulations. They had the option to choose one of the two plants proposed in pots  $\varnothing 16$  cm in diameter (Option A and Option B) with different characteristics and prices, or they could choose not to buy any of the options proposed (Option C), as described in Section 2.2 and Table 3. The third section aimed to gather

demographic and socio-economic information. We ensured that all respondents were informed at the beginning of the survey that their provided information would remain anonymous and be used exclusively for this research. We also assured them that we would adhere to the regulations of the EU Regulation (EU 2016/679).

#### 2.4. Econometric Models

MNL (multinomial logit) is based on the utility maximization function [42], which assumes that respondents will choose the alternative (A, B, or C as mentioned above) that maximizes their utility. In our study, the choice of the potted outdoor plant was influenced by its attributes (“diagnosis”, “technique”, and “price”), as well as the perceptions that distinguish the respondent. These choices are also constrained by imperceptible parameters such as socio-demographic and economic variables, which are considered random variables in this context.

The utility function ( $U_{nj}$ ) for the  $j$ -th alternative of the  $n$ -th respondent is composed of a deterministic component ( $X_{nj}$ ) that depends on observable attributes and a stochastic component ( $\varepsilon$ ) that represents measurement errors and captures all the unobservable attributes that influence the purchase decision. Therefore, the utility function can be expressed as follows:

$$U_{n,j} = V_{n,j} + \varepsilon_{n,j} = \beta'X_{n,j} + \varepsilon_{n,j} \quad (2)$$

where “ $U$ ” refers to the utility, “ $\beta'X$ ” the deterministic part, “ $\varepsilon$ ” the random part, “ $n$ ” the respondent, “ $i$ ” the alternatives, and “ $j$ ” the choice set.

Hence, this utility function in this study was modelled as follows:

$$V_{n,\text{Option A}} = \beta'_1 * \text{diagnosis} + \beta'_1 * \text{technique} + \beta'_1 * \text{price} \quad (3)$$

$$V_{n,\text{Option B}} = \beta'_1 * \text{diagnosis} + \beta'_1 * \text{technique} + \beta'_1 * \text{price} \quad (4)$$

$$V_{n,\text{Option C}} = \beta'_1 * \text{diagnosis} + \beta'_1 * \text{technique} + \beta'_1 * \text{price} \quad (5)$$

where attributes (e.g., “diagnosis”, “technique”, and “price”) are described in Table 1. Consequently, the possibility that the  $n$ -th respondent selected the  $i$ -th alternative from choice set “ $j$ ” is determined as follows:

$$\text{Prob}_{n,i} = \frac{\exp(V_{ni})}{\sum_{j=1}^J \exp(V_{nj})} \quad (6)$$

Therefore, standard MNL assumes similar attitudes and choice homogeneity among respondent preferences, showing an important drawback of this model. Consequently, a set of complex econometric models, such as RPL and Latent Class Model are often applied to relax the homogeneity assumption and to capture the heterogeneity of non-observable preferences, whereby the deterministic part of the utility can be modelled as follows:

$$U_{n,j} = V_{n,j} + \varepsilon_{n,j} = (\beta' + \eta_n)X_{n,j} + \varepsilon_{n,j} \quad (7)$$

where  $\beta'$  denotes the mean value attribute utility weight in the sample and  $\eta_n$  is the vector of person  $n$ -specific difference from the mean.

Concerning the RPL model, Halton draws were used to estimate the model, because this provides a more efficient distribution of draws for numerical integration [49]. Regarding WTP, we assumed a linear function of the utility, so that the respondents are willing to pay a price premium for each attribute (Table 1) based on the following equation:

$$WTP_A = -\frac{\beta_A}{\beta_P} \quad (8)$$

where  $\beta_A$  and  $\beta_P$  are the estimated coefficients related to each attribute and price, respectively.

Furthermore, an LCM was employed to investigate different behaviors among respondents, segment the market, and estimate consumer profiles. The LCM allowed the researchers to group consumers into different classes based on their purchasing choices. To determine the optimal number of classes, information criteria values such as maximum log likelihood, minimum Bayesian information criteria (BIC), and minimum corrected Akaike criteria (CAIC) were evaluated. By gradually increasing the number of classes, the model achieved an improved fit and performance in terms of stability, sensitivity, and specificity.

### 3. Results

#### 3.1. Descriptive Statistics Results

The descriptive statistics results regarding Italians' behavior and propensity towards ornamental plants revealed some interesting insights. Many respondents preferred to acquire horticultural plants directly from nurseries (31%) and from specialized shops/florists (30%), followed by shopping malls (16%). When it came to the aspects of ornamental plants that received the most attention from Italian consumers, apart from prices and cultivation methods, a significant percentage of respondents expressed a high level of interest in the state of health (71%), care requirements (51%), water requirements (39%), plant luxuriance (52%), and absence of visible defects on leaves and stems (62%). Regarding the care of ornamental plants, the data indicated that most respondents (49%) preferred to take personal care of the plants they purchased, without seeking external advice from specialists in the field.

#### 3.2. Econometric Results

The following econometric models were obtained with the software NLOGIT version 5. Table 4 presents the results of the MNL model, revealing interesting findings. All coefficient estimates associated with the attributes showed positive signs, except for the price, as was expected. Furthermore, these coefficients were highly significant at the 1% level. Additionally, the alternative specific constant (ASC) for the opt-out option (option C—no buy) was determined to be  $-0.33$ , and its significance was also high. This suggests that the respondents had a positive approach to the analyzed product. The coefficients for the “diagnosis” and “technique” attributes, as described in Table 1, were positive and highly significant ( $p = 0.00$ ). This indicates that the inclusion of plant diagnosis, monitoring, and environmentally friendly cultivation practices in nurseries instilled a strong sense of trust and generated significant utility for the studied population.

**Table 4.** Multinomial logit (MNL) and random parameter logit (RPL) model performance estimates.

|                                           | MNL   | RPL   |
|-------------------------------------------|-------|-------|
| Log likelihood function (L)               | −3880 | −3258 |
| Number of independent variables (K)       | 4     | 33    |
| Akaike information criterion (Inf.Cr.AIC) | 7768  | 6853  |
| Bayesian information criterion (BIC)      | 7792  | 6788  |

The RPL model, obtained with 200 Halton draws, yielded favorable results in terms of the log likelihood function, information criteria AIC, AIC/N, and BIC compared to the MNL model. Additionally, the attributes obtained from the RPL model were consistent with those from the MNL model, reaffirming the disutility experienced by Italian consumers when faced with the no-choice alternative. Moreover, all attribute coefficients were statistically significant at the indicated levels of significance (\*  $p < 0.10$ ; \*\*  $p < 0.05$ ; \*\*\*  $p < 0.01$ ), and their signs aligned with those obtained from the MNL model (Table 5). This further emphasizes the significance of “diagnosis” and “technique” practices for Italian consumers when making purchasing decisions for potted ornamental plants, resulting in increased utility for them.

**Table 5.** Random parameter logit model (RPL) and multinomial logit model (MNL) coefficient estimates.

| MNL                                                |                      |     |                   |        |                 |                            |       |
|----------------------------------------------------|----------------------|-----|-------------------|--------|-----------------|----------------------------|-------|
| Code of the Attribute<br>(as Described in Table 1) | Coefficient          |     | Standard<br>Error | z      | Prob.  z  > Z * | 95%<br>Confidence Interval |       |
| Diagnosis                                          | 0.97                 | *** | 0.09              | 10.49  | 0.00            | 0.79                       | 1.15  |
| Technique                                          | 0.75                 | *** | 0.07              | 10.79  | 0.00            | 0.61                       | 0.88  |
| Price                                              | −0.1                 | *** | 0.01              | −8.68  | 0.00            | −0.13                      | −0.08 |
| Alternative specific constant ASC<br>(Opt-out)     | −0.33                | *** | 0.06              | −5.13  | 0.00            | −0.45                      | −0.2  |
| RPL                                                |                      |     |                   |        |                 |                            |       |
| Random Parameter                                   | Coefficient          |     | Standard<br>Error | z      | Prob.  z  > Z * | 95%<br>Confidence Interval |       |
| Price                                              | −1.15                | *** | 0.13              | −8.69  | 0.00            | −1.41                      | −0.89 |
|                                                    | Nonrandom parameters |     |                   |        |                 |                            |       |
| Diagnosis                                          | 1.27                 | *** | 0.1               | 12.35  | 0.00            | 1.07                       | 1.48  |
| Technique                                          | 1.03                 | *** | 0.08              | 12.77  | 0.00            | 0.87                       | 1.19  |
| Alternative specific constant ASC<br>(Opt-out)     | −1.09                | *** | 0.08              | −13.42 | 0.00            | −1.25                      | −0.93 |

Note: \*, \*\* ==> Significance: at 90%, 99% level, respectively.

Price was used as a random parameter following a normal distribution. Furthermore, the analysis of interaction effects (Table 6) between the price attribute and various parameters related to the consumers' behavior, propensity to purchase ornamental plants, demographic factors, and socio-economic characteristics provided valuable insights for understanding the heterogeneity of consumer perceptions and preferences for potted ornamental plants, such as *A. × grandiflora*. Regarding the frequency of purchase, it was discovered that Italian consumers who are inclined to buy potted ornamental plants more than once a month are more affected by price. In terms of the preferred place of purchase, respondents showed a strong influence from direct purchases from nurseries. Interestingly, trust in nurseries emerged as a significant driver for potted plant purchases. This suggests that nurseries can play a vital role by providing information about their plant production practices and highlighting their commitment to sustainability. In terms of demographic parameters, the analysis revealed that gender and age had a relatively limited impact on the price purchase of potted plants. However, level of education appeared to play a significant role in determining price sensitivity among consumers.

With respect to the WTP, respondents were willing to pay an additional EUR 1.00 (Table 7) for changes in the production of outdoor plants, specifically *A. × grandiflora*. The WTP for different attributes of ornamental production systems varied slightly, with a WTP of EUR 1.10 for plant diagnosis and EUR 0.90 for cultivation techniques used in nurseries, indicating a strong consumer preference for plant health and a significant interest in sustainability in the nursery industry.

Regarding the latent class results, the analysis was performed with different numbers of classes ranging from 1 to 6. For each number of classes, the log likelihood and information criteria were computed, including the Inf.Cr.AIC, AIC/N and adjusted BIC. The results show that as the number of latent classes increased, the log likelihood decreased, indicating a better model fit, but reducing the consistency of each class and complicating the overall model. It appears that the model with five latent classes ( $K = 5$ ) had the lowest log likelihood (−2979) and was the best fit according to the information criteria. The percentage of the sample assigned to each of the five classes is provided, ranging from 8% to 31%. The log likelihood of the model with five classes compared to a restricted one performing a significant chi-squared test and the McFadden pseudo-R-squared indicated a moderate level of fit. Each class had different utility parameters for the predictor variables. Post-elaboration analysis allowed for the interpretation of the behavior and characteristics of each class based on the following table and the descriptive statistics of each class. The

segmentation analysis was conducted by considering the covariates, resulting in significant differences across classes. The study identified five distinct classes based on respondents' characteristics and behavior (Table 8).

**Table 6.** Interaction of demographic parameters and consumer covariates with price as a random normal distributed parameter in RPL model.

| Heterogeneity in Mean      | Coefficient | Standard Error | z     | Prob.  z  > Z * | 95% Confidence Interval |      |
|----------------------------|-------------|----------------|-------|-----------------|-------------------------|------|
| Price × Frequency          |             |                |       |                 |                         |      |
| Rarely                     | 0.25 **     | 0.10           | 2.51  | 0.01            | 0.05                    | 0.45 |
| Once a year                | 0.39 ***    | 0.11           | 3.55  | 0.00            | 0.18                    | 0.61 |
| More than once a year      | 0.33 ***    | 0.11           | 3.19  | 0.00            | 0.13                    | 0.54 |
| Once a month               | 0.47 ***    | 0.12           | 4.01  | 0.00            | 0.24                    | 0.70 |
| More than once a month     | 0.59 ***    | 0.13           | 4.48  | 0.00            | 0.33                    | 0.85 |
| Price × Place of purchase  |             |                |       |                 |                         |      |
| E-commerce                 | 0.20 *      | 0.16           | 1.26  | 0.21            | −0.11                   | 0.51 |
| Peddler                    | 0.27 ***    | 0.10           | 2.58  | 0.01            | 0.06                    | 0.47 |
| Shopping mall              | 0.24 ***    | 0.09           | 2.62  | 0.01            | 0.06                    | 0.42 |
| Specialized shop/florist   | 0.28 ***    | 0.09           | 3.20  | 0.00            | 0.11                    | 0.45 |
| Garden center              | 0.19 *      | 0.11           | 1.75  | 0.08            | −0.02                   | 0.41 |
| Nursery (direct producer)  | 0.30 ***    | 0.09           | 3.38  | 0.00            | 0.13                    | 0.48 |
| Price × Gender             |             |                |       |                 |                         |      |
| Gender (male)              | 0.06 *      | 0.04           | 1.62  | 0.10            | −0.01                   | 0.13 |
| Price × Age                |             |                |       |                 |                         |      |
| Age                        | 0.00 *      | 0.00           | −1.43 | 0.15            | 0.00                    | 0.00 |
| Price × Level of education |             |                |       |                 |                         |      |
| Year of study              | 0.01 **     | 0.00           | 2.20  | 0.03            | 0.00                    | 0.02 |

Note: \*, \*\*, \*\*\* ==> Significance: at 90%, 95%, 99% level, respectively.

**Table 7.** Willingness-to-pay estimates.

| Attribute                                            | EUR  |
|------------------------------------------------------|------|
| Phytosanitary diagnosis in nursery (Code: diagnosis) | 1.10 |
| Nursery cultivation technique (Code: technique)      | 0.90 |
| Overall average                                      | 1.00 |

The first class, comprising 21% of respondents, showed a positive price coefficient and a high frequency of purchasing. They preferred buying from nurseries or direct producers and placed high importance on quality aspects, but not on price. They personally cared for plants and predominantly lived in houses with private green spaces. This class consisted of educated individuals with a medium-high income.

The second class, representing 30% of respondents, exhibited a medium-high willingness to pay for both attributes and preferred sustainable cultivation techniques. They made moderately frequent purchases from florists and garden centers. Their attention during the purchase aligned with their willingness to pay, focusing on care and absence of defects. They also lived in houses with private green spaces and had a higher education level and medium income.

The third class accounted for 19% of the sample and showed a positive but limited willingness to pay. They were occasional buyers who did not prioritize a specific place of purchase and primarily sought low prices. They disregarded cultivation methods, care, and water requirements of plants. Their education level was medium-high, and they did not predominantly live in contexts with private green spaces.

Table 8. Latent class analysis (LCA) results.

| Variable<br>  Class | Coefficients | Standard Error | z     | Prob.  z  > Z * | 95%<br>Confidence Interval |          |
|---------------------|--------------|----------------|-------|-----------------|----------------------------|----------|
| Price  1            | 0.14830 **   | 0.05815        | 2.55  | 0.0108          | 0.03433                    | 0.26228  |
| Diagnosis  1        | 3.34491 ***  | 0.3965         | 8.44  | 0               | 2.56778                    | 4.12203  |
| Technique  1        | 1.46855 ***  | 0.30707        | 4.78  | 0               | 0.86671                    | 2.07038  |
| Opt-out  1          | −0.02551     | 0.414          | −0.06 | 0.9509          | −0.83694                   | 0.78591  |
| Price  2            | −0.11389 *** | 0.03094        | −3.68 | 0.0002          | −0.17454                   | −0.05325 |
| Diagnosis  2        | 0.69281 ***  | 0.20196        | 3.43  | 0.0006          | 0.29698                    | 1.08864  |
| Technique  2        | 1.11086 ***  | 0.15424        | 7.2   | 0               | 0.80855                    | 1.41318  |
| Opt-out  2          | −1.79515 *** | 0.32509        | −5.52 | 0               | −2.43232                   | −1.15797 |
| Price  3            | −0.82441 *** | 0.11607        | −7.1  | 0               | −1.0519                    | −0.59691 |
| Diagnosis  3        | 0.88302 **   | 0.34764        | 2.54  | 0.0111          | 0.20166                    | 1.56438  |
| Technique  3        | 1.19945 ***  | 0.33337        | 3.6   | 0.0003          | 0.54605                    | 1.85284  |
| Opt-out  3          | −4.16053 *** | 0.45458        | −9.15 | 0               | −5.05149                   | −3.26957 |
| Price  4            | −0.13416 *** | 0.03921        | −3.42 | 0.0006          | −0.21102                   | −0.05731 |
| Diagnosis  4        | 1.80417 ***  | 0.30992        | 5.82  | 0               | 1.19674                    | 2.41159  |
| Technique  4        | 1.26312 ***  | 0.20934        | 6.03  | 0               | 0.85281                    | 1.67343  |
| Opt-out  4          | 1.20360 ***  | 0.229          | 5.26  | 0               | 0.75477                    | 1.65244  |
| Price  5            | −0.24909     | 0.3517         | −0.71 | 0.4788          | −0.93841                   | 0.44022  |
| Diagnosis  5        | −0.14798     | 1.57975        | −0.09 | 0.9254          | −3.24423                   | 2.94828  |
| Technique  5        | −2.04314     | 1.72048        | −1.19 | 0.235           | −5.41523                   | 1.32894  |
| Opt-out  5          | 2.90442 ***  | 1.00348        | 2.89  | 0.0038          | 0.93764                    | 4.87121  |

Note: \*\*\*, \*\*, \* ==> Significance at 1%, 5%, 10% level.

The fourth class, representing 20% of the sample, consisted of relatively rare buyers who occasionally preferred florists over nurseries. Despite not expressing clear attention to specific aspects, their willingness to pay was high, likely influenced by the low frequency of their purchases. They showed a preference for phytosanitary diagnosis techniques rather than sustainable cultivation techniques.

The fifth and smallest class, comprising 8% of respondents, demonstrated a strong aversion towards the analyzed product. They had a high and positive coefficient related to non-purchase, indicating no willingness to pay for the analyzed attributes. They rarely made purchases, did not care for plants at home, and lacked houses with green spaces. This class had the lowest proportion of individuals with a diploma, indicating lower education and income levels compared to other classes.

## 4. Discussion and Conclusions

### 4.1. Key Findings at a Glance

In this paper, we assessed, through a sample of 464 reasonable Italian respondents, their perceptions and WTP for an outdoor ornamental plant, *Abelia × grandiflora*, as a case study of an open field grown shrub and considered a high potential feeding plant for Xf vectors [49], by investigating the effect of (i) novel plant diseases diagnostics (i.e., “diagnosis”) through early detection of potential diseases such Xf, and (ii) sustainable nursery cultivation management (i.e., “technique”), reducing environmental impacts. Here, we link the key findings for the research questions of the study. In this direction, we found that most respondents (71% of the sample) considered the health status when buying ornamental plants. In addition, the choice of cultivation method in nurseries had a relatively smaller impact on their purchasing decision. Interestingly, consumers were less likely to seek the advice of trusted experts or rely on the presence of a gardener/maintenance worker when purchasing ornamental species like *Abelia × grandiflora*.

In addition, the attributes “diagnosis” and “technique” had positive and highly significant ( $p = 0.00$ ) coefficients, suggesting that the incorporation of environmentally friendly cultivation procedures, plant diagnosis, and early detection, as well as continuous monitor-

ing in nurseries, created a great sense of confidence and produced a substantial amount of benefit for the population under study, as depicted by the means of the MNL and RPL outcomes in Table 5. Moreover, we found that respondents, on average, were willing to pay a price premium for innovative plant diagnosis and sustainable cultivation in the production of *Abelia* × *grandiflora*, amounting to EUR 1.10 and EUR 0.90, respectively, as estimated in Table 7, illustrating that they had a relatively higher degree of interest in plant health over the sustainability issues of ornamental plants they buy, in order to maximize their satisfaction. Furthermore, this paper revealed the existence of five *Abelia* × *grandiflora* respondent segments, which are pertinent for supporting the Italian plant nursery sector, based on their socio-economic and demographic characteristics, as well as attitudes, as evidenced by the outcomes of the LCA depicted above, in which the largest segment, represented by 30% of the respondents, denoted medium-high willingness to pay, especially for sustainability, and frequently buy from florists and garden centers. In this segment, participants prioritized plant care and lack of defects, had higher education, medium income, and lived in houses with private green spaces.

#### 4.2. Importance and Implications of the Findings

The results explored above provide a clear picture of Italian consumers' perception and WTP for an outdoor ornamental plant regarding plant diseases and eco-friendly plant cultivation practices, such as the optimal use of plant stimulators and reduced resource and input usage. Here, we derive some private and policy implications from our findings. First, our research highlights that a significant majority of respondents were willing to pay a 20% premium for plants certified as disease-free, protected from every possible biotic stress such as Xf that can befall them. Similarly, our study revealed a considerable number of respondents that favored sustainable cultivation practices for outdoor ornamental plants. The absence of such research for the Italian plant nursery industry is a critical constraint on the expansion of current knowledge regarding consumer choice behavior for non-edible outdoor potted plants, as there is a lack of scientific papers that have simultaneously examined phytosanitary diagnosis and sustainable cultivation attributes using a DCE approach. Second, our paper provides valuable insights for the Apulian plant nursery sector, by helping the nursery managers to plan their plant production management through the adoption of sustainable and disease-preventive practices, and by developing effective marketing strategies for their ornamental species and prioritizing certifications and labelling for plant disease-free and sustainability. Moreover, the segmentation of participants through the mean of the LCA outlined the main characteristics of consumers interested in ornamental plants, and consequently can contribute toward better positioning strategies for nursery products to compensate for higher costs related to production requirements. Lastly, the research findings are crucial for policymakers to formulate communication strategies and awareness campaigns, in order to promote the sale of healthy Apulian ornamental species in compliance with the current EU regulation 2020/1201, which requires mandatory inspections and control of quarantine pests such as Xf on plants propagated in nurseries located within the demarcated area of the outbreak of the pest.

#### 4.3. Comparison of the Findings

The descriptive statistics findings reported in Section 3.1 align with previous studies [50–55], which highlighted consumers' preferences for visible aesthetic qualities and features of ornamental plants (i.e., plant health, shape, flower and leaf color, final height, etc.). Additionally, our findings are consistent with Schimmenti et al. [10], who found that purchases of cut flowers and potted plants were commonly made in nurseries and flower shops. In contrast, Yue and Behe [56] demonstrated that consumer purchasing behavior for ornamental plants was more likely to occur in mass-merchandisers rather than garden centers. In terms of WTP, Yu et al. [57] investigated the WTP of US and Canadian consumers for sustainable attributes in ornamental plants (i.e., Chrysanthemum) and found a lower WTP of USD 0.11. Previous studies also highlighted the influence of environmental

labelling information on consumers' likelihood of purchasing ornamental plants, explored the importance of pest management practices and price in consumers' purchasing decisions and WTP for floriculture crops, and examined the demand for visually attractive and novel ornamental plants [57,58]. Moreover, Frem et al. [39] found an average annual gross margin of around EUR 0.20 per ornamental plant, such as *A. × grandiflora*, when using sustainable cultivation methods compared to conventional ones.

#### 4.4. Limitations of the Study and Future Research Areas

The sampling approach used in this research might not permit generalizing the observed findings over the rest of the country. Thus, future research could use a multistage or a stratified sampling method dividing the Italian population into homogeneous subpopulations (i.e., strata) that would differ in gender, age, ethnicity, geographical origin (i.e., city versus rural areas), and income ranges, allowing drawing more precise conclusions across the country and ensuring that every subgroup of consumers is properly represented in the study. In addition, other outdoor and indoor ornamental plants were not included when exploring the consumers' perceptions toward the specified attributes. Therefore, an expansion of the research could certainly go a long way toward filling these limitations. Since this study focused on Italian consumers' preferences for outdoor ornamental plants, it would be valuable to expand the research to include members of specialist plant societies. This would ensure a deeper understanding of the impact of novel plant disease diagnostics and sustainable nursery cultivation methods, as well as a more comprehensive coverage of the market through targeted social media campaigns. Moreover, a possible future direction of research could be to investigate the propensity of nursery companies to embrace emerging technologies and the necessary technical adaptations to improve the sustainability and health security of their production. Furthermore, the results suggest the potential for future analysis using latent class segmentation to uncover valuable insights into different market segments with varying preferences for purchasing various ornamental plants species. Furthermore, a future exploration of the economic viability of introducing sustainable and disease-resistant techniques on a large scale in nurseries would confirm the WTP of customers to pay the higher prices reported in this study.

To conclude, the phytosanitary diagnosis of ornamental plants has become increasingly crucial for Italian nurseries, particularly in the Apulia region due to global plant trade restrictions resulting from the severe outbreak of Xf that occurred in 2013. This situation has emphasized the need for innovative, cost-effective, and time-efficient plant pest quarantine diagnosis methods. Providing labelling information about plant health and environmentally friendly cultivation methods can significantly influence consumers' preferences and raise awareness about plant health and production. Nurseries, greenhouse garden centers, and plant retailers who effectively communicate this information would have a competitive advantage in driving sales of ornamental species. Finally, the implementation of a plant diagnosis protocol could generate a premium compared to the non-use of plant phytosanitary diagnosis in nurseries. In this line, nursery entrepreneurs would need to ensure profitability and economic sustainability to adopt these practices. As evidenced in this paper, the moderate price premium associated with these attributes could potentially cover the additional costs of implementing sustainable cultivation practices.

**Supplementary Materials:** The following supporting information can be downloaded at <https://www.mdpi.com/article/10.3390/horticulturae10050501/s1>, Questionnaire S1: Survey on Italian consumers preferences towards ornamental plant diagnosis and sustainable cultivation management.

**Author Contributions:** Conceptualization, M.F. and A.P.; methodology, M.F., A.P. and F.B.; software, M.F. and A.P.; validation, M.F., A.P. and F.B.; formal analysis, M.F., A.P. and F.B.; investigation, M.F., A.P., E.T., A.A.C. and F.C.; resources, A.P. and F.B.; data curation, M.F., A.P. and F.B.; writing—original draft preparation, M.F., A.P. and F.B.; writing—review and editing, M.F., A.P., B.D.L. and F.B.; visualization, M.F. and A.P.; supervision, M.F., A.P., F.B. and V.F.; project administration, A.P., F.B. and V.F.; funding acquisition, A.P. and F.B. All authors have read and agreed to the published version of the manuscript.

**Funding:** This research was funded by the Rural Development Programme (Regional)—Puglia—2014IT06RDRP020: Italy, Measure 16.2, Project name: “ProDiQuaVi”—Transfer of protocols for quarantine and harmful organisms and for the selection of sanitary materials improved for the Apulian nursery. The APC was funded by UNIBA (University of Bari Aldo Moro).

**Informed Consent Statement:** The data collected through the online questionnaire were used exclusively for statistical purposes and for this study. They will not be disclosed to third parties or used for private interests, our own or others, according to Regulation (EU) 2016/679 on the protection of individuals regarding the processing of personal data. The acquired information was exclusively used in an aggregate way, thus guaranteeing the complete anonymity of the respondents.

**Data Availability Statement:** Data are contained within the article.

**Acknowledgments:** Thanks are due to Enza Campanella for her administrative support.

**Conflicts of Interest:** The authors declare no conflicts of interest.

## References

- Cardwell, K.; Dennis, G.; Flannery, A.R.; Fletcher, J.; Luster, D.; Nakhla, M.; Rice, A.; Shiel, P.; Stack, J.; Walsh, C.; et al. Principles of diagnostic assay validation for plant pathogens: A basic review of concepts. *Plant Health Prog.* **2018**, *19*, 272–278. [\[CrossRef\]](#)
- EFSA (European Food Safety Authority Panel on Plant Health). Update of the *Xylella* spp. host plant database-systemic literature search up to 30 June 2021. *EFSA J.* **2022**, *20*, e07356.
- Castro, C.; DiSalvo, B.; Roper, M.C. *Xylella fastidiosa*: A reemerging plant pathogen that threatens crops globally. *PLoS Pathog.* **2021**, *17*, e1009813. [\[CrossRef\]](#) [\[PubMed\]](#)
- Greco, D.; Aprile, A.; De Bellis, L.; Luvisi, A. Diseases caused by *Xylella fastidiosa* in *Prunus* genus: An overview of the research on an increasingly widespread pathogen. *Front. Plant Sci.* **2021**, *12*, 712452. [\[CrossRef\]](#) [\[PubMed\]](#)
- Landa, B.B.; Saponari, M.; Feitosa-Junior, O.R.; Giampetruzzi, A.; Vieira, F.J.; Mor, E.; Robatzek, S. *Xylella fastidiosa*’s relationships: The bacterium, the host plants, and the plant microbiome. *New Phytol.* **2022**, *234*, 1598–1605. [\[CrossRef\]](#)
- Cardone, G.; Digiario, M.; Djelouah, K.; Frem, M.; Rota, C.; Lenders, A.; Fucilli, V. Socio-economic risks posed by a new plant disease in the Mediterranean basin. *Diversity* **2022**, *14*, 975. [\[CrossRef\]](#)
- Loconsole, G.; Zicca, S.; Manco, L.; El Habib, O.; Altamura, G.; Potere, O.; Elicio, V.; Valentini, F.; Boscia, D.; Saponari, M. Diagnostic procedures to detect *Xylella fastidiosa* in nursery stocks and consignments of plants for planting. *Agriculture* **2021**, *11*, 922. [\[CrossRef\]](#)
- Bozzo, F.; Frem, M.; Fucilli, V.; Cardone, G.; Garofoli, P.F.; Geronimo, S.; Petrontino, A. Landscape and vegetation patterns zoning is a methodological tool for management costs implications due to *Xylella fastidiosa* invasion. *Land* **2022**, *11*, 1105. [\[CrossRef\]](#)
- Frem, M.; Petrontino, A.; Fucilli, V.; Sansiviero, C.; Bozzo, F. Sustainable viticulture of Italian grapevines: Environmental Evaluation and societal cost estimation using EU farm accountancy data network. *Horticulturae* **2023**, *9*, 1239. [\[CrossRef\]](#)
- Schimmenti, E.; Galati, A.; Borsellini, V.; Levoli, C.; Lupi, C.; Tinervia, S. Behaviour of consumers of conventional and organic flowers and ornamental plants in Italy. *Hortic. Sci.* **2013**, *40*, 162–171. [\[CrossRef\]](#)
- Grymshi, D.; Crespo-Cebada, E.; Elghannam, A.; Mesías, F.J.; Díaz, C. Understanding consumer attitudes towards ecolabeled food products: A latent class analysis regarding their purchasing motivations. *Agribusiness* **2022**, *38*, 93–107. [\[CrossRef\]](#)
- Ali, O.; Ramsubhag, A.; Jayaraman, J. Biostimulant properties of seaweed extracts in plants: Implications towards sustainable crop production. *Plants* **2021**, *10*, 531. [\[CrossRef\]](#) [\[PubMed\]](#)
- Loconsole, D.; Cristiano, G.; De Lucia, B. Improving aerial and root quality traits of two landscaping shrubs stem cuttings by applying a commercial brown seaweed extract. *Horticulturae* **2022**, *8*, 806. [\[CrossRef\]](#)
- Ali, Q.; Ahmar, S.; Sohail, M.A.; Kamran, M.; Ali, M.; Saleem, M.H.; Rizwan, M.; Ahmed, A.M.; Mora-Poblete, F.; do Amaral Júnior, A.T.; et al. Research advances and applications of biosensing technology for the diagnosis of pathogens in sustainable agriculture. *Environ. Sci. Pollut. Res.* **2021**, *28*, 9002–9019. [\[CrossRef\]](#) [\[PubMed\]](#)
- Dheeraj, A.; Chand, S. LWDN: Lightweight DenseNet model for plant disease diagnosis. *J. Plant Dis. Prot.* **2024**, *131*, 1043–1059. [\[CrossRef\]](#)
- Sharma, V.; Tripathi, A.K.; Mittal, H. DLMC-Net: Deeper lightweight multi-class classification model for plant leaf disease detection. *Ecol. Inform.* **2023**, *75*, 102025. [\[CrossRef\]](#)

17. Fan, X.; Luo, P.; Mu, Y.; Zhou, R.; Tjahjadi, T.; Ren, Y. Leaf image-based plant disease identification using transfer learning and feature fusion. *Comput. Electron. Agric.* **2022**, *196*, 106892. [\[CrossRef\]](#)
18. Dhaka, V.S.; Kundu, N.; Rani, G.; Zumpano, E.; Vocaturo, E. Role of internet of things and deep learning techniques in plant disease detection and classification: A focused review. *Sensors* **2023**, *23*, 7877. [\[CrossRef\]](#) [\[PubMed\]](#)
19. Jafar, A.; Bibi, N.; Naqvi, R.A.; Sadeghi-Niaraki, A.; Jeong, D. Revolutionizing agriculture with artificial intelligence: Plant disease detection methods, applications, and their limitations. *Front. Plant Sci.* **2024**, *15*, 1356260. [\[CrossRef\]](#)
20. Devi, B.M.; Guruprasath, S.; Balu, P.; Chattopadhyay, A.; Thilagar, S.S.; Dhanabalan, K.V.; Choudhary, M.; Moparthi, S.; Jailani, A.A.K. Dissecting diagnostic and management strategies for plant viral diseases: What next? *Agriculture* **2024**, *14*, 284. [\[CrossRef\]](#)
21. Fuentes-Peñailillo, F.; Gutter, K.; Vega, R.; Silva, G.C. New Generation Sustainable Technologies for Soilless Vegetable Production. *Horticulturae* **2024**, *10*, 49. [\[CrossRef\]](#)
22. Li, X.; Li, Q.; Tang, B.; Gu, M. Growth responses and root characteristics of lettuce grown in aeroponics, hydroponics, and substrate culture. *Horticulturae* **2018**, *4*, 35. [\[CrossRef\]](#)
23. Bantis, F.; Koukounaras, A.; Siomos, A.; Menexes, G.; Dangitsis, C.; Kintzonidis, D. Assessing quantitative criteria for characterization of quality categories for grafted watermelon seedlings. *Horticulturae* **2019**, *5*, 16. [\[CrossRef\]](#)
24. Huang, L.; Gu, M. Effects of biochar on container substrate properties and growth of plants—A review. *Horticulturae* **2019**, *5*, 14. [\[CrossRef\]](#)
25. Cardoso, J.C.; Vendrame, W.A. Innovation in propagation and cultivation of ornamental plants. *Horticulturae* **2022**, *8*, 229. [\[CrossRef\]](#)
26. Darras, A.I. Implementation of sustainable practices to ornamental plant cultivation worldwide: A critical review. *Agronomy* **2020**, *10*, 1570. [\[CrossRef\]](#)
27. Benninga, J.; Reyman, D. Marketing features of ornamentals as appreciated by the market. *Acta Hortic.* **2000**, *536*, 479–484. [\[CrossRef\]](#)
28. Khachatryan, H. Comparing the effects of environmental and economic benefits related information on consumers' preferences and demand for ornamental plants. *Proc. Fla. State Hortic. Soc.* **2000**, *126*, 305–309.
29. Townsley-Brascamp, W.; Marr, N.E. Evaluation and analysis of consumer preferences for outdoor ornamental plants. *Acta Hortic.* **1995**, *391*, 199–208. [\[CrossRef\]](#)
30. Hovhannisyan, V.; Khachatryan, H. Ornamental plants in the United States: An econometric analysis of a household-level demand system. *Agribusiness* **2017**, *33*, 226–241. [\[CrossRef\]](#)
31. Dos Santos, P.L.F.; De Castilho, R.M.N. Germination and development of ornamental sunflower seedlings in substrates. *Ornam. Hortic.* **2018**, *24*, 303–310. [\[CrossRef\]](#)
32. Wagstaffe, J.; Cameron, R.W.; Hadley, P.; Bisgrove, R. Do Protocols for the intensive production of *Coreopsis grandiflora* affect its garden performance. *Sci. Hortic.* **2014**, *175*, 236–242. [\[CrossRef\]](#)
33. Palma, M.A.; Chen, Y.; Hall, C.; Bessler, D.; Leatham, D. Consumer preferences for potted orchids in the Hawaiian market. *Hort Technol.* **2010**, *20*, 239–244. [\[CrossRef\]](#)
34. Rihn, A.; Khachatryan, H.; Campbell, B.; Hall, C.; Behe, B. Consumers' preferences for organic production methods and origin promotions on ornamental plants: Evidence from eye-tracking experiments. *Agric. Econ.* **2016**, *47*, 599–608. [\[CrossRef\]](#)
35. Čop, T.; Njavro, M. Application of discrete choice experiment in agricultural risk management: A review. *Sustainability* **2022**, *14*, 10609. [\[CrossRef\]](#)
36. Johansson, J.V.; Bentzen, H.B.; Shah, N.; Haraldsdóttir, E.; Jónsdóttir, G.A.; Kaye, J.; Mascalonzi, D.; Veldwijk, J. Preferences of the public for sharing health data: Discrete choice experiment. *JMIR Med. Inform.* **2021**, *9*, e29614. [\[CrossRef\]](#) [\[PubMed\]](#)
37. Wang, Y.; Wang, Z.; Wang, Z.; Li, X.; Pang, X.; Wang, S. Application of discrete choice experiment in health care: A bibliometric analysis. *Front. Public Health* **2021**, *9*, 673698. [\[CrossRef\]](#) [\[PubMed\]](#)
38. Johnston, R.J.; Boyle, K.J.; Adamowicz, W.; Bennett, J.; Brouwer, R.; Cameron, T.A.; Hanemann, W.M.; Hanley, N.; Ryan, M.; Scarpa, R.; et al. Contemporary guidance for stated preference studies. *J. Assoc. Environ. Resour. Econ.* **2017**, *4*, 319–405. [\[CrossRef\]](#)
39. Frem, M.; Fucilli, V.; Petrontino, A.; Acciani, C.; Bianchi, R.; Bozzo, F. Nursery plant production models under quarantine pests' outbreak: Assessing the environmental implications and economic viability. *Agronomy* **2022**, *12*, 2964. [\[CrossRef\]](#)
40. Petrontino, A.; Frem, M.; Fucilli, V.; Tricarico, G.; Bozzo, F. Health-Nutrients and Origin Awareness: Implications for regional wine market-segmentation strategies using a latent analysis. *Nutrients* **2022**, *14*, 1385. [\[CrossRef\]](#)
41. Petrontino, A.; Madau, F.; Frem, M.; Fucilli, V.; Bianchi, R.; Campobasso, A.A.; Pulina, P.; Bozzo, F. Seafood choice and consumption behavior: Assessing the willingness to pay for an edible sea urchin. *Foods* **2023**, *12*, 418. [\[CrossRef\]](#) [\[PubMed\]](#)
42. Louviere, J.J.; Islam, T.; Wasi, N.; Street, D.; Burgess, L. Designing discrete choice experiments: Do optimal designs come at a price? *J. Consum. Res.* **2008**, *35*, 360–375. [\[CrossRef\]](#)
43. Bush, S. Optimal designs for stated choice experiments generated from fractional factorial designs. *J. Stat. Theory Pract.* **2014**, *8*, 367–381. [\[CrossRef\]](#)
44. Bhat, C.R. Simulation estimation of mixed discrete choice models using randomized and scrambled Halton sequences. *Transp. Res. Part B Methodol.* **2003**, *37*, 837–855. [\[CrossRef\]](#)
45. Street, D.J.; Burgess, L. Designs for choice experiments for the multinomial logit model. In *Design and Analysis of Experiments, Special Designs and Applications*, 3rd ed.; Hinkelmann, K., Ed.; John Wiley and Sons, Inc.: Hoboken, NJ, USA, 2012; pp. 331–378.

46. DeLong, K.L.; Syrengelas, K.G.; Grebitus, C.; Nayga, R.M. Visual versus text attribute representation in choice experiments. *J. Behav. Exp. Econ.* **2021**, *94*, 101729. [\[CrossRef\]](#)
47. Murwirapachena, G.; Dikgang, J. The effects of presentation formats in choice experiments. *Environ. Econ. Policy Stud.* **2022**, *24*, 421–445. [\[CrossRef\]](#)
48. Istituto Nazionale di Statistica. Italian Population in 2020. Available online: <https://dati.istat.it/> (accessed on 22 May 2021).
49. Kokiçi, H.; Çota, E.; Frem, M.; La Notte, P.; Sallaku, F.; Xhemali, B.; Haddad, N.; Frasheri, D.; Pasko, P.; Limani, B.; et al. Knowledge of xylem feeders (Hemiptera: Auchenorrhyncha) in Albanian olive orchards in readiness for a potential outbreak with *Xylella fastidiosa* invasion. *Ann. Société Entomol. Fr. (NS)* **2024**, *60*, 1–14. [\[CrossRef\]](#)
50. Wei, X.; Khachatryan, H.; Hodges, A.; Hall, C.; Palma, M.; Torres, A.; Brumfield, R. Exploring market choices in the US ornamental horticulture industry. *Agribusiness* **2023**, *39*, 65–109. [\[CrossRef\]](#)
51. Yu, C.; Campbell, B.; Hall, C.; Behe, B.; Dennis, J.; Khachatryan, H. Consumer preference for sustainable attributes in plants: Evidence from experimental auctions. *Agribusiness* **2016**, *32*, 222–235. [\[CrossRef\]](#)
52. Boumaza, R.; Demotes-Mainard, S.; Huché-Thélier, L.; Guérin, V. Visual characterization of the aesthetic quality of the rosebush. *J. Sens. Stud.* **2009**, *24*, 774–796. [\[CrossRef\]](#)
53. Wang, H.; Yang, Y.; Li, M.; Liu, J.; Jin, W. Residents' preferences for roses, features of rose plantings and the relations between them in built-up areas of Beijing, China. *Urban For. Urban Green.* **2017**, *27*, 1–8. [\[CrossRef\]](#)
54. Mayett-Moreno, Y.; Popp, J.S.; Sabogal-Salamanca, M.; Rodríguez-Piñeros, S.; Salomé-Castañeda, E.; Flores-Alonso, D.A. Consumers' and retailers' attitudes towards a Mexican native species of *Aztec Lily* as an ornamental plant. *Sustainability* **2018**, *10*, 224. [\[CrossRef\]](#)
55. Knuth, M.J.; Khachatryan, H.; Hall, C.R. How consistent are Consumers in their decisions? Investigation of houseplant purchasing. *Behav. Sci.* **2021**, *11*, 73. [\[CrossRef\]](#) [\[PubMed\]](#)
56. Yue, C.; Behe, B.K. Factors affecting US consumer patronage of garden centers and mass-merchandisers. *Acta Hortic.* **2009**, *831*, 301–308.
57. Wollaeger, H.M.; Getter, K.L.; Behe, B.K. Consumer preferences for traditional, neonicotinoid-free, bee-friendly, or biological control pest management practices on floriculture crops. *HortScience* **2015**, *50*, 721–732. [\[CrossRef\]](#)
58. Kalaman, H.; Wilson, S.B.; Mallinger, R.E.; Knox, G.W.; Kim, T.; Begcy, K.; van Santen, E. Evaluation of native and nonnative ornamentals as pollinator plants in Florida: II. Floral Resource Value. *HortScience* **2022**, *57*, 137–143. [\[CrossRef\]](#)

**Disclaimer/Publisher's Note:** The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.

**CHAPTER 4: A Systematic Review of Innovation Adoption in Agri-Food Enterprises**  
(Published in *Agriculture*)

# Classification, Evaluation and Adoption of Innovation: A Systematic Review of the Agri-Food Sector

Adele Annarita Campobasso <sup>1,\*</sup> , Michel Frem <sup>2,\*</sup> , Alessandro Petrontino <sup>1</sup> , Giovanni Tricarico <sup>3</sup> and Francesco Bozzo <sup>1</sup> 

<sup>1</sup> Department of Soil, Plant and Food Sciences, University of Bari Aldo Moro, 70126 Bari, Italy; alessandro.petrontino@uniba.it (A.P.); francesco.bozzo@uniba.it (F.B.)

<sup>2</sup> Sinagri s.r.l., Spin Off of the University of Bari Aldo Moro, 70126 Bari, Italy

<sup>3</sup> Confcooperative Puglia, 70125 Bari, Italy; tricarico.g@confcooperative.it

\* Correspondence: adele.campobasso@uniba.it (A.A.C.); mefrem@sinagrispinoff.it (M.F.)

## Abstract

The transition towards sustainable agri-food systems requires understanding factors influencing innovation adoption across agri-food companies. This systematic literature review, following PRISMA methodology, examines innovation types, their intended purposes, and adoption determinants among worldwide stakeholders. Data were extracted from Scopus and Web of Science databases using rigorous selection criteria, covering publications from January 2014 to January 2025. From 775 initial records, 80 publications were selected for quantitative analysis, of these 74 empirical studies included in qualitative analysis. Innovations were categorized based on ecological, economic, social, and institutional purposes, revealing ecological purpose innovations predominated. Subsequently, adoption factors were classified using the tripartite framework based on extrinsic, intrinsic, and intervening variables. Findings reveal developing regions (Sub-Saharan Africa and Asia) representing 65% of studies. Agriculture sector dominated research attention, with cereals as the most investigated value chain, reflecting their fundamental role in global food security and nutrition. Analysis demonstrates that adoption decisions result from complex interactions between external structural conditions, individual psychological factors, and support mechanisms. Results underscore the context-dependent nature of innovation adoption and the need for context-sensitive, multi-stakeholder approaches facilitating sustainable and digital food system transformations.

**Keywords:** agri-food firms; ecological factors; innovation adoption; institutional factors; networking; novel collaboration; socio-economic determinants



Academic Editors: Guoqing Zhao and Huilan Chen

Received: 1 August 2025

Revised: 26 August 2025

Accepted: 27 August 2025

Published: 29 August 2025

**Citation:** Campobasso, A.A.; Frem, M.; Petrontino, A.; Tricarico, G.; Bozzo, F. Classification, Evaluation and Adoption of Innovation: A Systematic Review of the Agri-Food Sector. *Agriculture* **2025**, *15*, 1845. <https://doi.org/10.3390/agriculture15171845>

**Copyright:** © 2025 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

## 1. Introduction

In recent years, the policies promoted in favour of the ecological, digital, and sustainable food systems transition (e.g., the European Green Deal, the Farm to Fork strategy, the United Nations Sustainable Development Goals), as well as funding programs for research and innovation such as Horizon Europe (2021–2027), have proposed a new model of growth and economic development that is smarter, more sustainable and more inclusive. According to the FAO Statistical Yearbook 2024, global agricultural value has increased by 89 percent in real terms over the past two decades, reaching \$3.8 trillion in 2022, while the proportion of the global workforce employed in agriculture has decreased from 40 percent in 2000 to 26 percent in 2022 [1]. The new Common Agricultural Policy programming (2023–2027), supporting sustainable farming and innovation, has established, among its

thematic objectives, the transversal goal of modernizing agriculture and rural areas by promoting and sharing knowledge, innovation, and digitalization in agriculture, with the European Commission allocating more than €200 million through Horizon 2020 for research and innovation in digital technologies for the agricultural sector, and an additional €762.7 million assigned through the Digital Europe work programs for 2024 [2].

Agri-food supply chains represent interconnected networks that intermediate the flow of products between largely rural farmers, fisherfolk, or herders and increasingly urban consumers, serving as key loci for technology transfer and foreign investment [3]. In this context, innovation adoption refers to the complex process by which farmers, agri-food companies, and other supply chain actors integrate new technologies, practices, or organizational methods into their operations to improve efficiency, sustainability, and competitiveness. This definition encompasses a broad spectrum of innovations, from technological advancements like precision agriculture and digital tools to novel practices such as conservation agriculture and new forms of collaborative business models, aligning with the multi-dimensional nature of innovation in agricultural systems [3–5]. Agricultural sustainability encompasses systems that aim to make the best use of environmental goods and services while not damaging these assets, integrating biological and ecological processes into food production while minimizing harmful non-renewable inputs and making productive use of farmers' knowledge and collective capacities [6]. The OECD-FAO Agricultural Outlook 2025–2034 projects that global agricultural and fish production will increase by 14% over the next decade, primarily driven by productivity gains, particularly in middle-income countries. However, increases in productivity will help lower emission intensity and keep the anticipated rise in direct agriculture GHG emissions to 6% [7]. These projections underscore the critical role that innovation adoption plays in addressing future challenges concerning sustainability and business competitiveness [8].

Despite the recognized importance of innovation adoption for achieving sustainable development goals and enhancing agri-food system resilience, significant challenges persist in understanding and facilitating uptake across varied agricultural contexts. Adoption rates remain below expectations in many countries, with considerable heterogeneity in innovation uptake patterns across different types of value chain, innovations, and geographical contexts. This variety is compounded by the multiple nature of agri-food supply chains, where innovation adoption decisions are influenced not only by individual characteristics but also by supply chain dynamics, collaborative relationships, and institutional factors.

Previous systematic reviews have identified critical limitations in the current understanding of innovation adoption processes. For instance, Rosario et al. [9] highlighted the inability to compare the most utilized models and types of sustainable innovations to evaluate whether different innovations are represented by the same adoption or learning process. Similarly, Giua et al. [10] emphasized the need to extend focus beyond individual dimensions to include organizational factors relative to supply chains where farmers operate, noting that actors and organizational factors might play important explanatory roles in understanding adoption and diffusion across the entire agri-food sector's digitalization. Vecchio et al. [11] demonstrated that context related variables create positive "cultural" environments favouring innovation adoption, particularly through territorial systems of innovation that engender both geographical and organizational proximity. More recently, Rizzo et al. [12] and John et al. [13], in their systematic literature review, have emphasized the need for more comprehensive approaches to understanding farmers' adoption of sustainable and digital innovations respectively, particularly highlighting the role of social dynamics, awareness levels, and knowledge dissemination pathways.

According to Meijer et al. [5] research on innovation adoption in agriculture has traditionally emphasized extrinsic variables such as technology characteristics and ex-

ternal environmental conditions, with less attention paid to intrinsic variables including knowledge, attitudes, and perceptions of potential adopters, and limited consideration of intervening variables within the process such as extension and communication mechanisms. While this comprehensive framework was originally used for understanding agroforestry adoption among smallholder farmers in sub-Saharan Africa, integrating extrinsic, intrinsic, and intervening variables in the decision-making process, its broader application across diverse geographical contexts, innovation types, and agricultural systems remains underexplored. Similarly, the multifunctional approach to agricultural sustainability that recognizes systems as jointly producing food and contributing to public goods such as clean water, wildlife habitats, and carbon sequestration [6] has been not widely applied in empirical research examining innovation purposes. Furthermore, despite recognition that agri-food value chains serve as key loci for technology transfer and foreign investment [3], systematic analysis of how innovation adoption patterns vary across different value chain innovations and geographical contexts remains limited. Comprehensive systematic reviews integrating innovation types, purposes, and adoption factors across multiple dimensions and supply chain contexts remain absent from the literature in the moment in which this work is carried out by authors. To address this knowledge gap, this study contributes to building crucial knowledge for policymakers who can use the results to design more targeted and effective policies in promoting agricultural innovation adoption, ultimately supporting global sustainability objectives and food system transformation goals.

The present study aims to achieve several strategic objectives, focusing primarily on identifying the types of innovations examined in agri-food adoption research. These innovations are categorized according to their intended purposes within sustainability frameworks, building on Pretty's [6] principles of agricultural sustainability that emphasize the integration of biological processes, minimization of harmful inputs, and productive use of farmers' knowledge and collective capacities. Innovations are classified across four dimensions: ecological, economic, social, and institutional purposes, following the multifunctional approach to agricultural systems that jointly produce food and contribute to valued public goods. Additionally, this research examines the determinants influencing innovation adoption decisions, utilizing the analytical framework proposed by Meijer et al. [5] that recognizes the multiple interplay between extrinsic variables (characteristics of the technology and attributes of the external environment), intrinsic variables (knowledge, perceptions, and attitudes of potential adopters), and intervening variables (extension, training, and communication mechanisms that are crucial in developing knowledge, perceptions and attitudes) in the decision-making process. Particular attention is given to understanding how these adoption determinants operate across different innovation types and geographical contexts within agri-food supply chains, recognizing the role of agri-food value chains as intermediaries that facilitate technology transfer and structural change in agricultural systems among supply chain actors [3], excluding final consumers.

Accordingly, the systematic review addresses three research questions: (RQ1) What types of innovation are evaluated in the agri-food or agricultural sectors' adoption? (RQ2) What purposes and objects have been investigated to evaluate innovation adoption of agrifood innovations? (RQ3) What factors affect farmers' or stakeholders' propensity to adopt innovations?

The systematic review contributes to the scientific literature by providing a comprehensive mapping of innovation types and their associated adoption determinants across the three domains of influence, identifying patterns in how different categories of innovations address sustainability challenges within agri-food value chains that serve as critical intermediaries for technology transfer. This comprehensive approach advances theoretical understanding of the mechanistic interactions between extrinsic, intrinsic, and intervening

variables that drive adoption decisions while providing practical insights for targeting technologies appropriately to ensure sustainability across varied agricultural contexts.

## 2. Materials and Methods

To answer the research questions and provide new scientific insights into multidisciplinary research approaches, the PRISMA method by Page et al. [14] was adopted to ensure a transparent and rigorous approach. The flowchart of search process follows the four steps recommended by this protocol's guidelines: identification, screening, eligibility, and data extraction (Supplementary Material: Table S1: PRISMA 2020 Checklist).

### 2.1. Identification

The documents' identification was performed using the Scopus citation database, published by Elsevier, along with the Web of Science, selected for its extensive interdisciplinary coverage of high-quality, peer-reviewed literature in the social and agricultural sciences. The search strategy combined keywords and Boolean operators, developed through an analysis of previous systematic reviews on innovation adoption in agriculture [9,12,13] and two focus groups involving university researchers, rural development experts and stakeholders from the agri-food sector such as farmers, representatives of producer organizations and cooperatives, agro-industrial firms, and distributors.

The final list of keywords useful to develop the search strings included: "Innovation"; "Agri-food"; "Assessment"; "Measurement"; "Evaluation"; "Propensity"; "Inclination"; "Attitude"; "Willingness"; "Predisposition"; "Driver"; "Barrier"; "Determinant"; "Behaviour"; "Intention"; "Accepta\*"; "Adopt\*"; and "Agriculture".

Finally, the following filters were set:

- Year: from 2014 to 2025.
- Document type: articles and reviews.
- Publication stage: final.
- Language: English.

In Table 1 are reported the complete search strings applied to "Title, Keywords, Abstract" fields, and the specific filters about period, language, publication stage and type for each database extraction. The time frame between 2014 and 2025 was chosen to capture recent developments shaped by major policy frameworks (the European Green Deal, the Farm to Fork strategy, the United Nations Sustainable Development Goals) and technological advancements, as recommended by Ofosu-Ampong et al. [15], who identified this period as a significant turning point in agricultural behaviour change research. Thus, this interval was deemed appropriate to encompass the most relevant conceptual and methodological advancements in the field. By applying the above criteria, 775 publications were identified.

**Table 1.** Research protocol for each database.

| Category      | Description                                                                                                                                                                                                                                        |                                                                                                                                                                                                                                                    |
|---------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Search string | Agri-food OR Agriculture AND Innovation AND Assessment OR Measurement OR Evaluation AND Propensity OR Inclination OR Attitude OR Willingness OR Predisposition OR Driver OR Barrier OR Determinant OR Behavio* OR Intention OR Accepta* OR Adopt*. | Agri-food OR Agriculture AND Innovation AND Assessment OR Measurement OR Evaluation AND Propensity OR Inclination OR Attitude OR Willingness OR Predisposition OR Driver OR Barrier OR Determinant OR Behavio* OR Intention OR Accepta* OR Adopt*. |

**Table 1.** *Cont.*

| Category          |                              | Description                  |
|-------------------|------------------------------|------------------------------|
| Document type     | Article and review           | Article and review           |
| Database          | Scopus                       | Web of Sciences              |
| Period            | January 2014–25 January 2025 | January 2014–25 January 2025 |
| Language          | English                      | English                      |
| Publication stage | Final                        | Final                        |

Source: own elaboration.

## 2.2. Screening

The initial search conducted in Scopus and Web of Science databases produced 775 results. After removing duplicates and applying filters in Table 1, 413 studies were retained for the screening phase. In this stage, documents were assessed based on the title, abstract, and keywords, and no subject area filters were applied, to avoid prematurely excluding potentially relevant contributions from fields outside economics or the social sciences. This inclusive and multidisciplinary approach was intentionally adopted to capture evidence across a broad disciplinary spectrum, potentially offering valuable insights into the intrinsic and extrinsic factors influencing innovation adoption by actors within agri-food systems. Papers from disciplines such as medicine or engineering were included only if aligned with the research questions. Studies without a specific focus on agri-food innovation adoption were excluded. In doubtful cases, the research team applied a cautious and inclusive approach, preferring to retain studies for the next review stage rather than risk discarding potentially useful contributions. After screening of title, abstract and keywords, 154 publications met the eligibility criteria.

## 2.3. Eligibility

Publications were further screened by fully reading the contents of the articles. At this stage, two researchers independently reviewed the 154 publications, resulting in 80 studies selected for final systematic analysis. All metadata (including details such as reference type, authors, year, reference, paper title, link, abstract, and keywords) were exported into an Microsoft Excel 365 spreadsheet to facilitate subsequent screening and eligibility assessments based on the specified criteria (Supplementary Material: Table S2: Studies included in review).

### Criterion 1. Specific to the agricultural or agri-food sector

It was included in this analysis only those publications that conduct research specifically within the agricultural or agri-food fields [16]. If a document merely references the relevant terms but focuses on a different sector, such as health or education, it was excluded.

### Criterion 2. Specific to innovation adoption

It included only those publications that specifically examine the process of innovation adoption [9] within agricultural or agri-food enterprises' contexts. If a document merely mentions innovation without addressing its adoption dynamics or the factors influencing it, it was excluded.

### Criterion 3. Exclusion of studies focused exclusively on impact measurement

Studies that base their analysis primarily on measuring impacts were excluded, as the objective is to explore the factors that promote innovation adoption in agri-food enterprises rather than to evaluate post-adoption outcomes or policies' impact evaluations. Given the complexity and breadth of impact evaluation, a separate systematic review would be required to comprehensively address this aspect [16]. Moreover, including such studies

would dilute the review's focus by diverting attention from the mechanisms and dynamics that drive the innovation adoption process.

#### Criterion 4. Stakeholder dynamics in innovation adoption

Studies that provide feedback on the dynamics involving key stakeholders, such as farmers, managers, and other individuals involved in innovation adoption, or that contribute relevant insights to this aspect and category were included. Studies that do not address these aspects, particularly those focused on the consumer perspective, were excluded.

The criteria adopted in this systematic review, following the PRISMA 2020 methodology [14], focused on identifying studies that examine the factors influencing the adoption process. This approach aimed to ensure a comprehensive and multidisciplinary understanding of the drivers and barriers to innovation adoption within agricultural and agri-food enterprises.

#### 2.4. Data Extraction, Quantity and Qualitative Analysis

Following the eligibility phase, metadata from the 80 included studies were exported into an Excel spreadsheet to continue the analysis phase.

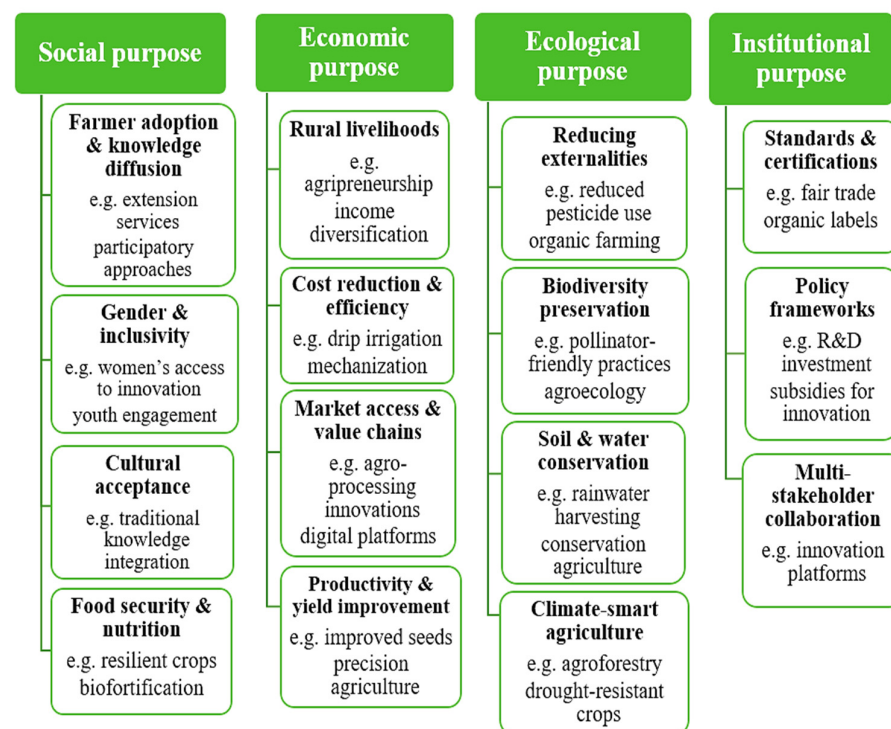
Quantitative analysis focused on:

- Year of publication, to trace the temporal distribution of the selected studies during recent changes driven by European policies such as the European Green Deal and the new Common Agricultural Policy programming.
- Geographical focus, identifying the country or countries in which the study was conducted. When multiple countries were addressed within a single study, each country was recorded as a separate unit of analysis.
- Sectoral and value chain focus, to investigate the distribution of innovations across four sectors (agriculture, livestock, agri-food, and forestry) and to map specific value chains when identified. This allowed for a better understanding of the context and scope in which innovation is analyzed.

Qualitative analysis focused on:

- Purpose of each type of innovation, classified into thematic categories reflecting their main aims (ecological, social, economic, and institutional) and stated aims of the selected articles, to understand the primary research objectives addressed by the existing literature. This categorization was developed through a conceptual framework (Figure 1) derived from an analysis of the literature, which allowed the reviewed innovations to be grouped according to their intended purpose. Indeed, the research employs Pretty's [6] and Barrett et al. [3] multifunctional sustainability principles to categorize innovations according to their ecological, economic, social, and institutional objectives, recognizing that agricultural systems can simultaneously produce food as well as contribute to preserving public goods, with a view to sustainability and innovation. Each of the four macro-categories includes specific subcategories that reflect the underlying goals and motivations behind innovation adoption. For example, biodiversity preservation and climate-smart agriculture fall under the ecological dimension, while productivity and yield improvement or rural livelihoods are considered as economic dimensions. Given the complex nature of agricultural innovation, some innovations were associated with more than one purpose or subcategory. This classification was manually applied across the dataset and enables an understanding of how agricultural innovations are positioned within different dimensions of sustainability, highlighting the relative prevalence of each category in the current literature.

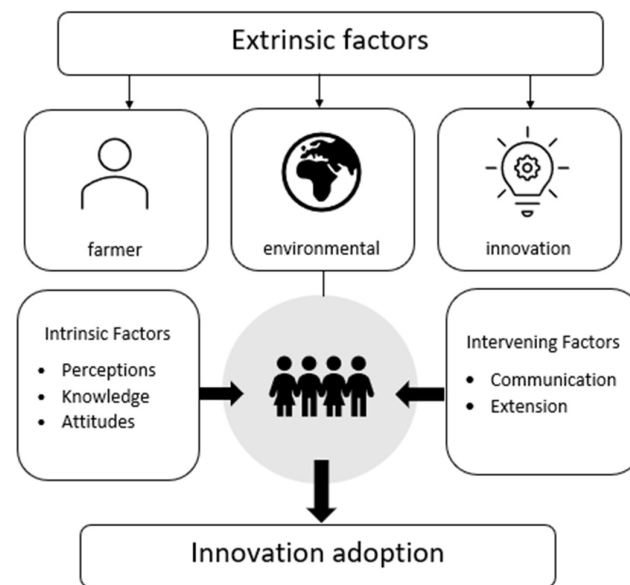
- Publications were assigned to multiple categories when their respective innovations served different purposes or when studies explicitly addressed multiple objectives. Each categorical assignment received one point, reflecting the multi-dimensional nature of agricultural innovations. The classification framework employed a dual-criterion approach, grounding categorization decisions on either: (i) explicit research objectives stated in the papers, (ii) inherent technical characteristics of the innovations, or (iii) convergent alignment of both dimensions.
- Factors affecting innovation adoption, which were identified, coded, and classified as intrinsic, extrinsic, or intervening variables. Their relevance was then analyzed in relation to innovation types, geographical locations, and agricultural system domains. This classification contributes to addressing knowledge gaps related to the multiple and context-specific nature of innovation adoption, as highlighted in recent studies. The study adopts a comprehensive approach that systematically examines innovation adoption based on the vision of Meijer et al.'s [5] framework, which emphasizes the complex interplay between extrinsic, intrinsic, and intervening variables in farmers' decisions to adopt new agricultural technologies or practices (Figure 2). This review extends the original tripartite framework beyond its sub-Saharan African agroforestry context to encompass factors affecting innovation adoption decision making process within diverse geographical settings, innovation types, and agricultural systems.



**Figure 1.** Conceptual scheme supporting the clustering of innovations based on their intended purpose (social, economic, ecological, institutional) derived from an analysis of the literature [3,6], with some examples. Source: own elaboration.

Some of the records retrieved through the search strategy included literature reviews. These studies were read and included in quantitative analyses (temporal, geographical, and sectoral distribution) because they were considered to support the full understanding of research interest on the topic. However, they were excluded from all analyses requiring the identification and classification of specific themes such as innovation purposes and adoption factors. This decision was adopted because including review papers in qualitative

analysis would have increased the risk of overlap or data distortion, as their contents often summarize evidence from primary studies already included in the sample.



**Figure 2.** Conceptual framework for analysing innovation adoption factors. The tripartite model shows the interaction between extrinsic, intrinsic, and intervening variables influencing farmers' adoption decisions. Source: own elaboration.

Their exclusion ensures the direct relevance of the evidence analyzed, strengthens the validity of the results, and improves the transparency of the study selection process.

The adopted classification showed in Figure 1 distinguishes four main purposes, each comprising a set of more specific categories:

- Social purpose: farmer adoption and knowledge diffusion, food security and nutrition, gender, and inclusivity, cultural acceptance;
- Economic purpose: productivity and yield improvement, cost reduction and efficiency, market access, and value chains, rural livelihoods;
- Ecological purpose: reducing externalities, climate-smart agriculture, soil and water conservation, biodiversity preservation;
- Institutional purpose: policy frameworks, multi-stakeholder collaboration, standards, and certifications.

This framework enabled a structured interpretation of the innovations' objectives and offered a means to explore the multiplicity of purposes and expected outcomes associated with the adoption of agricultural innovations in different contexts.

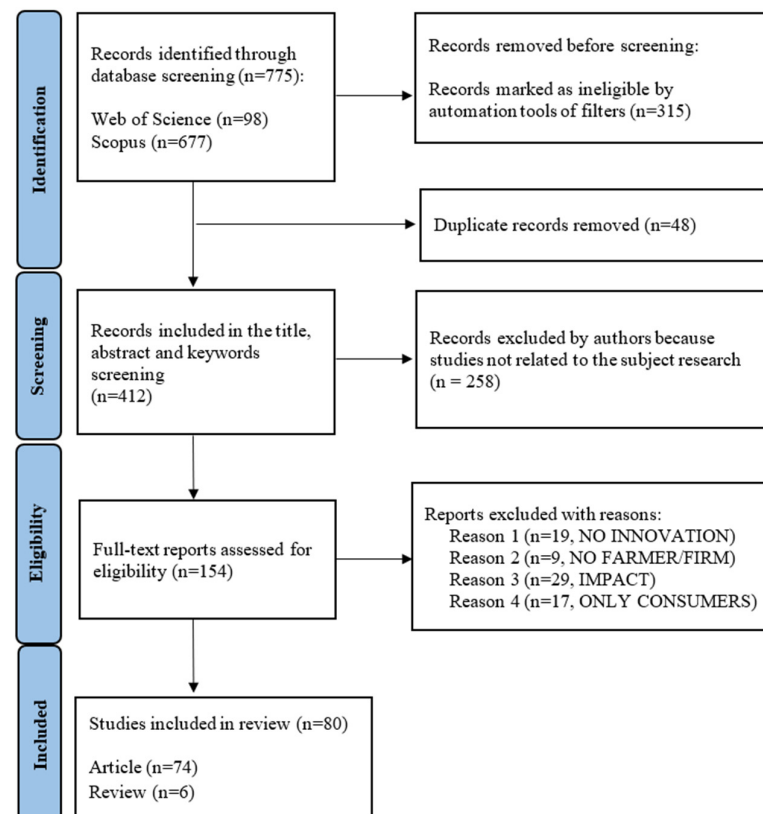
The conceptual model presented in Figure 2 illustrates the decision-making framework as a dynamic system with the farmer positioned as the central actor. The visual representation shows how three distinct categories of variables interact through directional flows to influence adoption outcomes.

Extrinsic factors encompass three key dimensions: farmer characteristics (e.g., age, education, farm size), environmental conditions (including governance and infrastructure aspects), and innovation characteristics (costs and benefits, technical and functional aspects). These external variables create the structural context that shapes the adoption environment. Intrinsic factors include the internal psychological and cognitive processes of potential adopters (attitudes toward innovation, risk perceptions, knowledge levels, and subjective norms) that directly influence individual decision-making. Intervening factors comprise

extension services, training programs, and communication aspects that affect knowledge transfer and capacity building.

The framework's directional arrows illustrate the dynamic relationships between these domains: extrinsic factors influence intrinsic variables, while intervening factors serve as facilitating mechanisms that can enhance or moderate these interactions. This tripartite visualization provides the analytical structure for systematically examining how different variables combine to influence farmers' innovation adoption decisions across the diverse contexts analyzed in this review.

The comprehensive study selection process, which includes all the methodological steps (identification, screening, eligibility, and data extraction), is summarized in Figure 3.



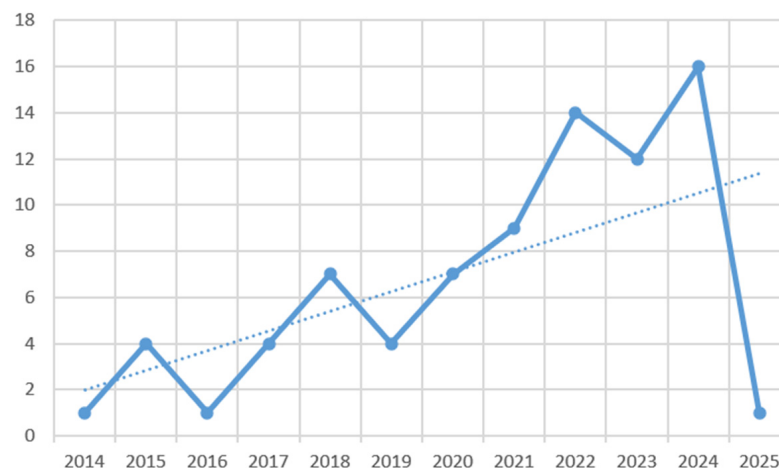
**Figure 3.** PRISMA flow diagram: selection process adopted in the present study. The 775 records identified in step 1 were subjected to automation tools of filters ( $n = 315$ ) and a duplicate removal ( $n = 48$ ) and a screening based on the reading of the title, abstract and keywords ( $n = 412$ ) according to the subject research. Then, the 154 records selected were read and screening full text according to thematic relevance through the criteria adopted in this systematic review. The final records selected ( $n = 80$ ) were included in the quantitative and qualitative analyses. Note. Of the 80 records included in the quantitative analysis, 6 were literature reviews. These reviews were excluded from the qualitative analysis to avoid duplication of findings already captured through primary empirical studies. As a result, the qualitative analysis was conducted on 74 empirical articles only. Source: own elaboration.

### 3. Results

The PRISMA method [14] for the systematic literature analysis enabled a quantitative and qualitative classification of the most relevant advances in socio-economic and scientific research on innovation adoption in the agrifood sector to respond to the research questions. This section presents the results of the systematic analysis, focusing on 80 publications that explored innovation adoption in agriculture shaped by contextualized factors, typology of innovation, and variable affecting innovation adoption individuating through all considered publications.

### 3.1. Quantity Analysis

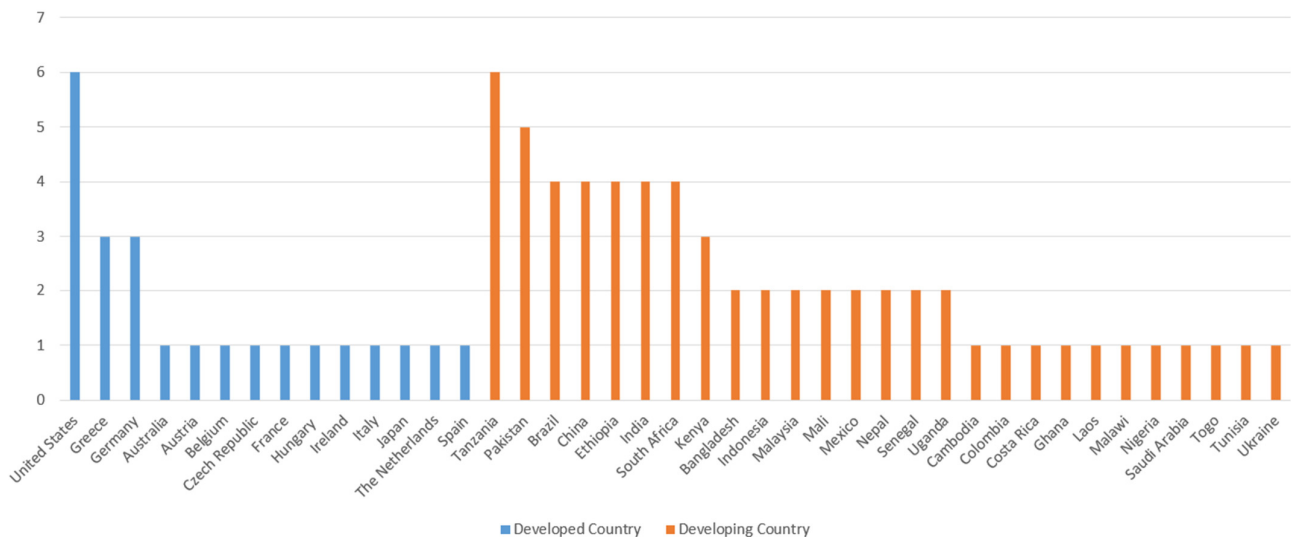
The temporal distribution of the selected studies reveals a progressive increase in the number of publications addressing innovation adoption in the agrifood sector. As shown in Figure 4, the review includes studies published from 2014 to January 2025. The number of contributions remains limited between 2014 and 2017, followed by a clear upward trend starting in 2018. Excluding two slight fluctuations in 2019 and 2023, the number continues to grow, reaching a peak at 16 in 2024. Only 1 study is recorded for 2025, reflecting the partial coverage of the first month of the year at the time of data collection.



**Figure 4.** Worldwide scientific production from 2014 to January 2025, selected for this review. The *y*-axis shows the number of publications; the *x*-axis shows the years in which they were published. The blue dotted line represents the trend line showing the progressive increase in publications addressing innovation adoption in the agri-food sector over the years (2014–2025). Source: own elaboration.

To address the recurring call for greater contextualization in innovation adoption studies, this review systematically examines the country, sector, and value chain associated with each paper. The geographical distribution of the reviewed studies is presented in Figure 5, which reports the frequency of analyzed publications by country. Country-level context was identifiable in 74 out of 80 records. There were studies in which the research was conducted across multiple countries: Ethiopia, Nigeria, and Tanzania [17]; Senegal and Mali [18]; Kenya, Ethiopia, Tanzania, and Uganda [19]; Kenya and Tanzania [20]; and The Netherlands, United States, Saudi Arabia, and India [21]. In these cases, each country was counted individually. This approach allowed for a more comprehensive mapping of the geographical scope and ensured consistency with the review’s objective of contextualizing innovation adoption processes within local settings.

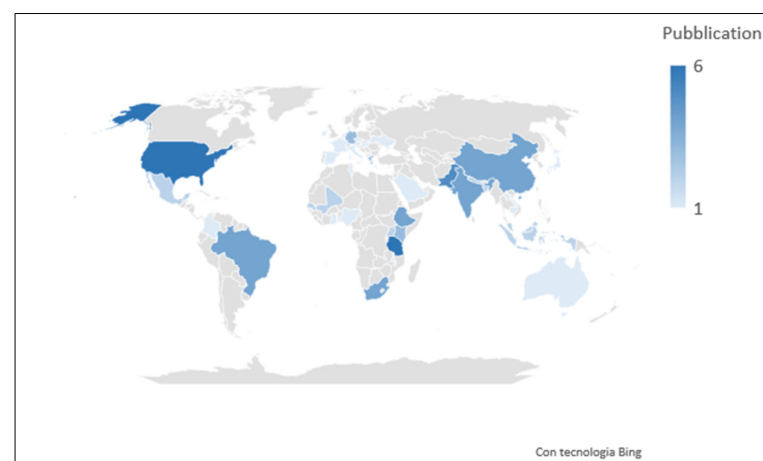
Countries classified as developed according to the World Bank 2024 [22] are shown in blue, while those classified as developing or emerging are shown in orange. Overall, the dataset includes 41 countries, comprising 27 developing countries and 14 developed ones. This indicates that developing countries appear with a frequency nearly twice that of developed countries. The United States and Tanzania are the most represented, with 6 studies each. Among the developed countries, the United States ranks first (6 studies), followed by Greece and Germany (3). All other developed countries are represented by a single study.



**Figure 5.** Number of publications per country. Histogram showing the number of publications by country ( $n = 41$ ). Each bar on the  $x$ -axis corresponds to a country in which at least one study was conducted. The height of the bars ( $y$ -axis) represents the number of studies associated with each country. In cases where a publication covers multiple countries, each country is counted once per study. Source: own elaboration.

In contrast, among the developing countries, several are the focus of multiple publications: Tanzania (6), Pakistan (5), and Brazil, China, Ethiopia, India, and South Africa (4 studies each). Kenya follows with 3 studies. The remaining countries appear with lower frequencies, often represented by a single study. These results highlight a wide geographical coverage with a predominance of studies conducted in developing countries.

A complementary view of the previous analysis is provided by Figure 6. This map visualizes the spatial distribution of the reviewed studies by nuancing each country according to the number of publications attributed to it, with colour intensity ranging from 1 publication to 6 publications, as indicated in the legend. The map based on the same data presented in Figure 5 provides a spatial representation that facilitates the visual identification of coverage gaps and geographical clusters following in Table 2.



**Figure 6.** Geographical scope of the study of the selected articles. Geographical distribution of the number of publications across countries, shades intensity ranges from light blue (1 publication) to dark blue (6 publications). Source: own elaboration.

**Table 2.** Distribution of selected publications by macro-region. Overview of the number of studies conducted in each macro-region, showing a clear predominance of research in Sub-Saharan Africa and Asia.

| Macro-Region       | N. Publications |
|--------------------|-----------------|
| Sub-Saharan Africa | 27              |
| Asia               | 24              |
| Europe             | 16              |
| Latin America      | 8               |
| North America      | 6               |
| Middle East        | 1               |
| North Africa       | 1               |
| Oceania            | 1               |

Source: own elaboration.

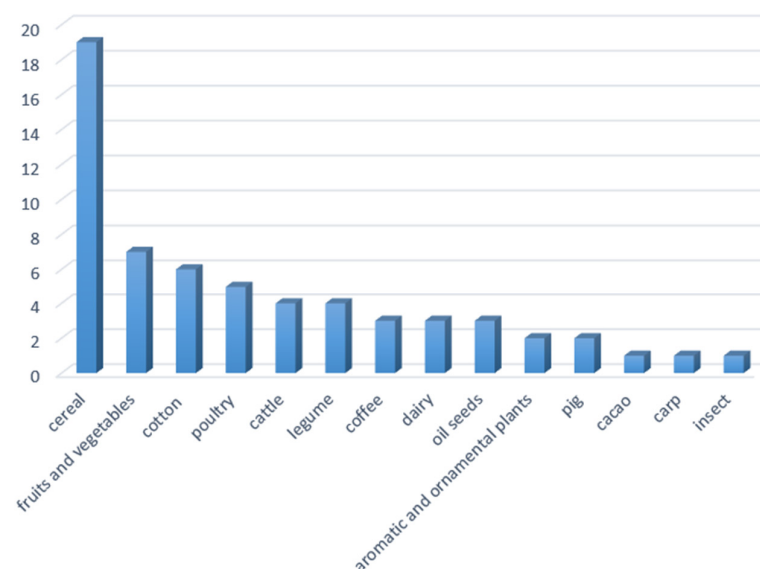
The figure shows that a limited number of countries, such as the United States, Tanzania, Pakistan, and Brazil, stand out with higher nuancing intensity; while a substantial portion of the map is covered by light shading or remains unshaded. This visually reinforces the concentration of research in a small group of countries and the sparse or absent representation in developed regions, particularly in Europe (excluding a few Western countries) and developing regions of Latin America (with some exceptions such as Brazil and Mexico), and parts of Asia and Africa.

To provide a comprehensive worldwide perspective, Table 2 aggregates the country-level data into macro-regions. This aggregation aims to highlight regional research trends and their alignment with areas facing major sustainability challenges. Macro-regions were defined following the World Bank 2024, supplemented by FAO frameworks where appropriate. This methodological choice ensures consistency with internationally recognised standards and supports the comparability of findings across different geographical contexts. Sub-Saharan Africa (Tanzania, Ethiopia, South Africa, Kenya, Mali, Senegal, Uganda, Ghana, Malawi, Nigeria, Togo) and Asia (Pakistan, China, India, Bangladesh, Indonesia, Malaysia, Nepal, Cambodia, Japan and Laos) emerge as the most frequently represented regions, with 27 and 24 studies, respectively. Together, these two macro-regions account for approximately 65% of all reviewed publications. Europe (Greece, Germany, Austria, Belgium, Czech Republic, France, Hungary, Ireland, Italy, The Netherlands, Spain and Ukraine) contributes 16 studies, followed by Latin America 8 studies (Brazil, Mexico, Colombia, and Costa Rica) and North America with 6 publications from only United States, followed by the Middle East (Saudi Arabia), North Africa (Tunisia), and Oceania (Australia) with a single study each one. These macro-regions with minimal representation were also included in the analysis to ensure completeness, although their limited number of studies (one each) prevents broader generalizations.

The reviewed studies were also examined in relation to the specific sector and the value chain investigated. Information about the sector was available in 79 out of 80 records, with one study (49) lacking sufficient detail to allow classification. Among the 79 identified cases, a total of 81 sectoral references were coded, as three studies addressed more than one sector. In these cases, each sector was considered individually. This methodological choice is consistent with the objective of this review, which seeks to contextualize innovation adoption within the agricultural and agri-food system. The sectors most frequently represented are agriculture (61 studies), agri-food (10), livestock (9), and forestry (1).

In parallel, value chains were identified and analyzed in 39 studies, where explicit reference to a specific commodity chain or product system was made. When multiple value chains were mentioned in a single study, the most prominently addressed one was selected for classification. The most represented value chains were cereals (19 studies),

which include a variety of staple crops such as wheat, maize, rice, millet, and Kernza. These were followed by fruits and vegetables (7), cotton (6), poultry (5), cattle, and legumes including soybean and beans (4 each), coffee, dairy, and oil seeds as olives and rapeseed (3 each), aromatic and ornamental plants and pig (2 each), and cacao, carp, and insect (1 each). This distribution is graphically illustrated in Figure 7, which presents the value chains in descending order of frequency. When considered together, value chains related to animal production (poultry, pig, and cattle) account for a total of 11 studies, placing livestock-related chains the second most represented group after cereals in terms of research attention in innovation adoption. This approach allowed mapping the distribution of research interest across different agricultural and food related value chains. The inclusion of sector and value chain information responds directly to one of the gaps highlighted in the literature, namely the need to better integrate local context and production systems in the analysis of innovation adoption processes.



**Figure 7.** Column chart displaying the frequency of value chains examined across 39 studies. Source: own elaboration.

### 3.2. Qualitative Analysis

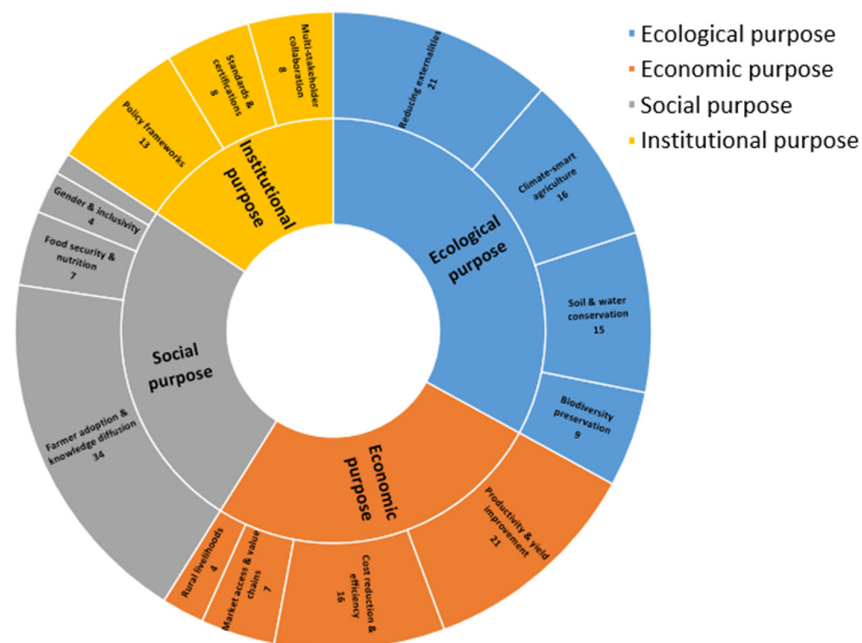
#### 3.2.1. Mapping Innovation Typologies According to Their Intended Purposes

In line with the conceptual framework presented in Figure 2, the systematic analysis included 70 publications that explicitly referred to a single or group of specifically mentioned innovations in agri-food. In the remaining 10 studies excluded from analysis, six of these were removed because reviews, while in the other cases research investigation explored wider issues without linking them to specific technologies or practices. Their exclusion enables the analytical relevance of the proposed classification, which was designed to describe the purposes that each innovation is intended to reflect.

Therefore, 70 publications and relative investigated innovations presented a complex distribution across four purposes connected sustainability and governance dimensions. This classification allows understanding how agricultural innovations are positioned within different dimensions considered in this analysis and highlights the relative prevalence of each category in the current literature.

The radial chart illustrated in Figure 8, places the four purposes at the centre and graphically shows the corresponding subcategories at the outer level. The ecological purpose innovations were the most prevalent in the studies with 61 assignments, with strong attention to reducing externalities ( $n = 21$ ), while less emphasis was given to climate-smart

agriculture ( $n = 16$ ), soil and water conservation ( $n = 15$ ), and biodiversity preservation ( $n = 9$ ). These were followed by well-balanced economic and social purposes with 48 and 47 assignments, respectively. Economic purpose innovations ( $n = 48$ ) were distributed across productivity and yield improvement ( $n = 21$ ), cost reduction and efficiency ( $n = 16$ ), market access and value chains ( $n = 7$ ), and rural livelihoods ( $n = 4$ ). While social purpose innovations ( $n = 47$ ) showed concentrated distribution, with farmer adoption and knowledge diffusion representing the most of all categories ( $n = 34$ ), followed by food security and nutrition ( $n = 7$ ), gender and inclusivity ( $n = 4$ ), and cultural acceptance ( $n = 2$ ). In contrast, institutional dimensions ( $n = 29$ ) are significantly less explored, with three specific thematic categories: policy frameworks ( $n = 13$ ), multi-stakeholder collaboration ( $n = 8$ ), and standards and certifications ( $n = 8$ ).



**Figure 8.** Agrifood innovation clustering based on their purpose (social, economic, ecological, institutional) and respective categories in the reviewed studies. The level of the circle closest to the center includes the name of the purpose, in the next level, the categories are represented. The coloured areas indicate the relative frequency of each subcategory, while the numbers in the figure represent their score across the dataset. Source: own elaboration.

The results presented in Table 3 support above mentioned categorization, confirming the significant variation in thematic distribution: ecological purposes dominate the research, with strong attention to reducing externalities and promoting climate-smart practices. Moreover, ecological and economic purposes demonstrated a good balance across multiple categories, with no single category dominating beyond 21 innovations within each dimension. On the contrary, social purpose innovations showed the highest frequency, in the farmer adoption and knowledge diffusion category, with a total score of 34 out of 47 innovations, and the lowest frequency of all records in “Cultural acceptance” with a score of only 2 out of 47. Institutional purposes showed moderate concentration, with policy frameworks representing 13 out of 29 institutionally oriented innovations.

**Table 3.** Detailed classification of each agricultural purpose innovation involved in the analysis (social, economic, ecological, institutional), with related score. The third column reports the frequency of innovation associated with each group.

| Cluster       | Categories                            | Score |
|---------------|---------------------------------------|-------|
| Ecological    | Biodiversity preservation             | 9     |
|               | Climate-smart agriculture             | 16    |
|               | Reducing externalities                | 21    |
|               | Soil & water conservation             | 15    |
| Economic      | Cost reduction & efficiency           | 16    |
|               | Market access & value chains          | 7     |
|               | Productivity & yield improvement      | 21    |
|               | Rural livelihoods                     | 4     |
| Institutional | Multi-stakeholder collaboration       | 8     |
|               | Policy frameworks                     | 13    |
|               | Standards & certifications            | 8     |
| Social        | Cultural acceptance                   | 2     |
|               | Farmer adoption & knowledge diffusion | 34    |
|               | Food security & nutrition             | 7     |
|               | Gender & inclusivity                  | 4     |

Note: Multiple labelling was applied to account for innovations with multiple purposes. Source: own elaboration.

Cross-dimensional analysis identified innovations investigated in current literature serving multiple sustainability purposes at the same time efficiently. Precision agriculture and decision support technologies were prominently represented across ecological purposes with their contribution in favour of environmental impact minimization, as exemplified by studies examining decision support tools for fertilizer application [23] and geospatial decision support tools for conservation practices [24]. In the “Productivity & yield improvement” category, agriculture 4.0 implementation approaches [25–28] dominate, including modern instruments for the agricultural context like Internet of Things (IoT) platforms adoption [29], smart glasses for augmented reality applications [30], and agricultural advice apps [31]. Finally, precision agriculture innovations demonstrate the increase of “Farmer adoption & knowledge diffusion” processes. In fact, advanced sensing technologies, IoT platforms, and augmented reality applications [29,30,32,33], can contribute to more socially embedded and effective innovation ecosystems, as well as enterprise resource planning (ERP) systems [34,35] provide organizational infrastructure for technology integration within worldwide enterprises.

Conservation agriculture systems and sustainable management practices dominated two categories in ecological purpose: firstly, “Soil & water conservation” [36–41] with studies examining farmers’ behavioral attitudes toward conservation agriculture adoption [37], performance evaluation of conservation agriculture components on a 10 year period in Mexican farms [39], and perceptions towards conservation agriculture amongst smallholder farmers [41]. Secondly, “Biodiversity preservation” in which some papers examine behavioral attitudes [37], perceptions and intention towards these sustainable agricultural practices amongst smallholder farmers of different developing country [40–42]. In addition conservation agriculture approaches [20,36,41,43] are included in “Farmer adoption & knowledge diffusion” demonstrating many efforts to promote sustainable soil and crop management practices by research, often requiring assessment tools and learning processes

to overcome adoption barriers [38] by strengthening integrated efficiency practices included sustainable approaches such as innovative climate change mitigation practices and conservation agriculture systems [37,39,40,44], and agricultural machinery adoption for mechanization efficiency [45]. In this context can be inserted climate-smart agriculture designed innovations and practices addressing climate change challenges through adaptation and mitigation strategies. Very clear examples are the study on climate smart agriculture implementation in favour of a more sustainable coffee production system [46], while research on climate-smart villages [47] examined institutional frameworks for promoting climate adaptation enhancing collaboration at community levels. These innovations had inherent climate adaptive characteristics of the involved technologies in mitigating climate change impacts, aligned with research objectives explicitly targeting to investigate climate resilience [47,48], risk mitigation [44,49,50], and sustainable agricultural transformation under changing environmental conditions [46,47,51–53].

The results reveal that the most significant score is attributed to “Farmer adoption & knowledge diffusion”, demonstrating this work’s alignment with research objectives. In fact, it emerged as the most prevalent subcategory within the purpose classification, with 34 assignments across publications. This group includes studies unified by their focus on bridging the gap between innovation availability and actual farmer adoption, providing insight regarding behavioural, structural, and contextual factors that influence adoption decisions and knowledge transfer mechanisms within the agrifood value chain, reinforcing farmer knowledge learning and opportunities for agricultural dissemination. Three categories represented the most unexplored categories in current literature about agricultural innovation adoption: “Rural livelihoods”, “Gender & inclusivity” and “Cultural acceptance”.

Within the economic purposes “Rural livelihoods” category the only 4 innovations had in common an approach centred on improving the adaptive capacity and resilience of rural farming systems through the integration of participatory development strategies and appropriate technical solutions. For instance, it included tropically adapted improved breeds (TAIBs) that analyse technical, economic, social, and environmental feasibility under smallholder management conditions [17]. Similarly, improved technology adoption in traditional poultry farming (ITPF) among smallholder farmers in Togo [54] to strengthen existing livelihood systems. The psychological dimensions of sustainable adoption are explored through agroforestry innovations that aim to improve the livelihoods of smallholders in Ethiopia [42]. Finally, new forms of cooperation create cooperative systems that ensure small-scale farming sustainability while strengthening local food supply systems in Austria [55], representing organizational innovations that enhance community resilience through market integration.

The “Gender & inclusivity” and “Cultural acceptance” categories comprise 4 and 2 studies, respectively. The first examines the inclusivity of agricultural innovations in Ethiopia [56], and how gendered roles and responsibilities influence agricultural innovation adoption and their perception. These studies reveal the critical importance of understanding demographic factors, particularly gender roles in different contexts. Gender topic implications are revealed concerning drought-tolerant maize adoption [50] and climate-smart push-pull technology for controlling stemborers [19] in sub-Saharan Africa, further illustrating how gendered roles and responsibilities influence innovation adoption, revealing opportunities to address gender based differences still too little studied. The second group explores how social innovation capacity and new forms of cooperation facilitate the adoption of agricultural innovations within specific cultural and geographical contexts, contributing to sustainable transformation. Research on private-public collaboration models [57] explored the establishment of alternative food

networks through local food stores with regional products, examining how proximity and social innovation capacity enable sustainable transformation in rural areas. This organizational innovation approach is complemented by a study on creating cooperative systems which ensure the sustainability of small-scale farming [55], which illustrates various forms of cooperation between farmers and consumers that ensure the sustainability of local food supply systems.

Complementing these cross dimensional insights, the institutional purpose across its three dimensions (multi-stakeholder collaboration, policy frameworks, and standards & certifications) highlighted significant overlaps with the categories previously linked to sustainability dimensions. These complementarities emerged through the adoption of numerous digital technologies, addressing a successful integration within agricultural systems (e.g., [31,51]). For instance, the blockchain technology adoption [21] addressed agricultural supply chain comparing the trends in developed and developing economies, while research on Internet of Things platforms [29] contributes to understanding willingness to adopt and innovation resistance in the context of information system research. These studies emphasize the need for institutional support for digital transformation while addressing behavioral and cultural dimensions of technology adoption. At the same way, the adoption of sustainable innovation like conservation agriculture, eco-innovation, enterprise resource planning systems and climate smart agricultural technologies [20,34–36,47,58] can enhance collaboration in favour of climate adaptation involving multiple actors with either similar or different roles. In this context, the framework for sustainable transformation of smallholder farming systems [43] integrates technical innovations with social realization pathways, promoting overcoming adoption barriers and recommending best practice bundles. Moreover, these complementarities were also evident in the presence of organizational innovations' adoption, including new forms of interaction among stakeholders and new public–private collaboration models designed to foster sustainable transformation [21,59]. Creating new forms of cooperative systems [55] focuses on establishing various forms of collaboration among farmers and with consumers that ensure the sustainability of small-scale farming through local food supply systems. Alternative food networks adoption [57] focuses on the concept of proximity to understand public-private collaboration models that aim at facilitating sustainable rural areas transformation through local food stores with regional products. Finally, innovation network systems [60] represent institutional innovations aimed at ensuring fair representation of the diversity of farmers' views, addressing the challenge of articulating them, and maintaining the focus on how farmers' interests can be articulated in innovation processes.

### 3.2.2. Mapping the Main Factors That Influence the Innovation Adoption Process Across Own Contexts

The analysis of the 74 articles included in this systematic literature review aimed to identify the key factors influencing the adoption process of actors involved and to link them within their own context. Among these, 57 studies explicitly reported one or more influencing factors of decision-making process in their findings, allowing for a comprehensive classification based on the conceptual framework in Figure 3. This approach enabled the extraction of multiple factors within individual studies, resulting in a mapping of variables affecting innovation adoption. Particular attention was given to the evidence resulting from comparing studies conducted in developed and developing countries, as well as to the specific typologies of the innovations considered. This analysis has enabled a deeper understanding of the multidimensional and context dependent nature of innovation adoption processes in the agrifood sector. The following paragraph presents the evidence emerging from the selected studies by grouping the factors into extrinsic and intrinsic

factors related to adopters, underlining their interaction in decision-making process, and the crucial role which may have extension and training in affecting the implementation of a new practice or technology [5].

The results are mentioned hereinafter across the three categories: extrinsic and intrinsic factors, and variables related to communication and extension intervening in the decision-making process of innovation's adoption. Table 4 provides a breakdown based on the factors' frequency extracted from the relevant studies, sorted according to the main group's specific category, extrinsic, intrinsic, and intervening adopted in this review. Each category (e.g., farmer, innovation, and external environment characteristics for extrinsic factors) presents the general value and the partial value divided by country, and that connected to the single level included in the analysis (e.g., for farmer characteristics: socioeconomic characteristics, social networks, personal characteristics, familiarity with technology, status characteristics, and personality characteristics). The table presents both developing and developed country frequencies, allowing for comparative visual interpretation across typologies and categories of variables investigated in the current literature in support of results achieved.

**Table 4.** Frequency of factors influencing innovation adoption classified by typology and category, with breakdown by country status (developed vs. developing). The table shows the frequency with which each factor, identified within the reviewed studies, was associated to relative category, distinguishing own geographical context between developing and developed countries.

| Typology of Factor | Subcategories and Levels             | Developing Countries | Developed Countries | Score |
|--------------------|--------------------------------------|----------------------|---------------------|-------|
| Extrinsic          | Farmer characteristics               | 34                   | 9                   | 43    |
|                    | Socioeconomic characteristics        | 16                   | 3                   |       |
|                    | Social networks                      | 7                    | 3                   |       |
|                    | Personal characteristics             | 7                    | 2                   |       |
|                    | Familiarity with technology          | 2                    | 0                   |       |
|                    | Status characteristics               | 1                    | 0                   |       |
|                    | Personality characteristics          | 1                    | 1                   |       |
|                    | Innovation characteristics           | 23                   | 11                  | 34    |
|                    | Technical/functional aspects         | 9                    | 5                   |       |
|                    | Benefits                             | 7                    | 4                   |       |
|                    | Costs                                | 7                    | 2                   |       |
|                    | External environment                 | 22                   | 7                   | 29    |
|                    | Political governances                | 8                    | 3                   |       |
|                    | Geographical settings                | 8                    | 2                   |       |
|                    | Market governance                    | 4                    | 1                   |       |
|                    | Societal culture                     | 2                    | 1                   |       |
| Intrinsic          | Attitudes                            | 30                   | 18                  | 91    |
|                    | Perceptions                          | 28                   | 6                   |       |
|                    | Knowledge                            | 6                    | 3                   |       |
| Intervening        | Communication and support mechanisms | 19                   | 8                   | 27    |

Source: own elaboration.

A comparison of the overall frequencies clearly shows that extrinsic factors were the most frequently examined across the selected studies, with a total of 106 assignments. These were predominantly reported in studies conducted in developing countries ( $n = 79$ ) in line with previous findings about geographical distribution, compared to a lower presence in developed contexts ( $n = 27$ ). Intrinsic factors follow reflecting the country composition of the dataset with a total score of 91, again with a stronger representation in developing countries ( $n = 64$ ) than in developed ones ( $n = 27$ ). Notably, considering the case of developed countries, extrinsic and intrinsic factors were reported with equal frequency ( $n = 27$  each), suggesting a more balanced interest of research between internal and external conditions determinants of individuals in shaping the innovation adoption process in this context, differently from developing countries. Intervening factors, mainly related to communication and support mechanisms, appeared less frequently overall ( $n = 27$ ), demonstrating a proportion nearly doubled: most references emerged from studies in developing countries ( $n = 19$ ), with fewer contributions from developed contexts ( $n = 8$ ).

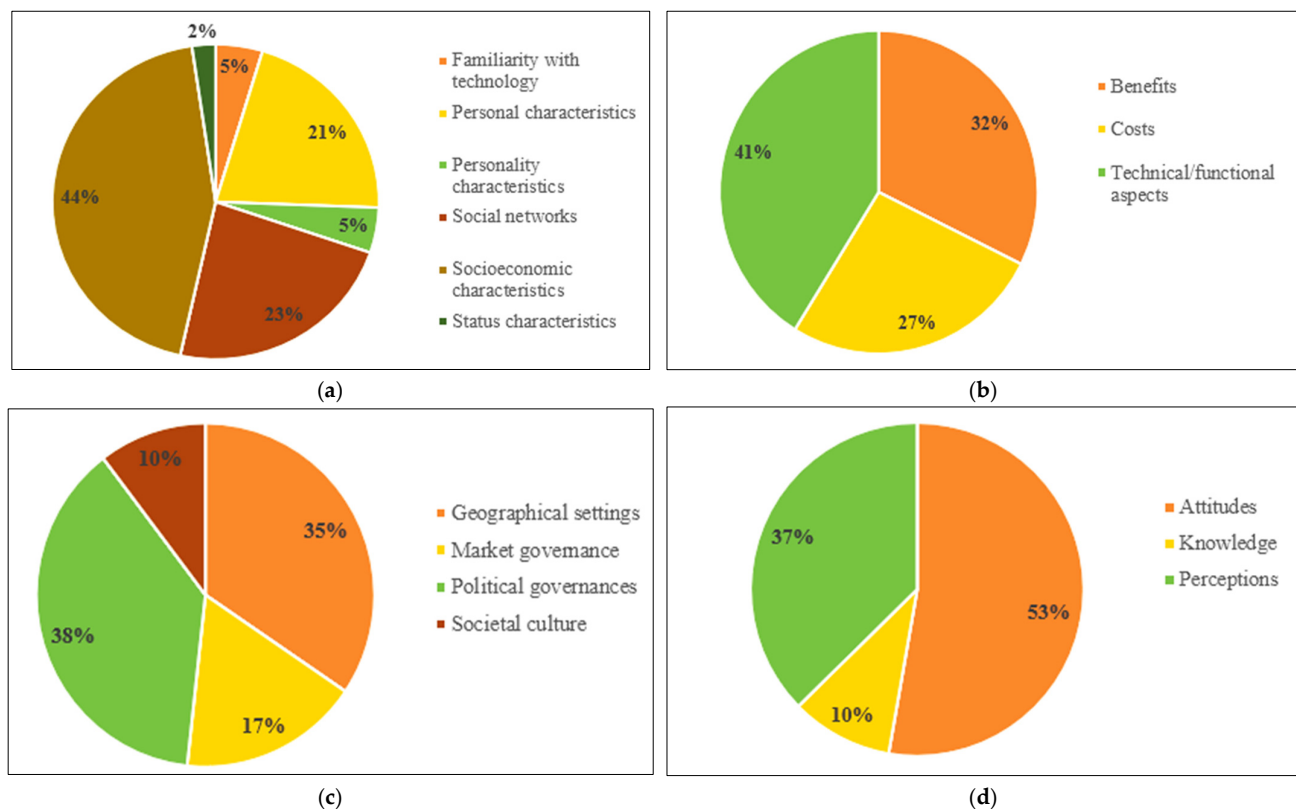
Within the extrinsic factors group, the most prevalent category is “Farmer characteristics” ( $n = 43$ ) with a large predominance of studies set in developing countries ( $n = 34$ ), highlighting the relevance of socioeconomic, personal, and social network characteristics in influencing adoption decisions. The category “Innovation characteristics” is followed by 34 factors (23 developing and 11 developed), indicating widespread attention to technical and functional features, benefits, and implementation costs concerning practices or technology uptake. Though the overall emphasis remained stronger in developing countries, in this case the weight of references’ proportion appears to be reduced compared to the other characteristics, considering the unbalanced representation of developing countries in the dataset. This distribution suggests that innovation specific attributes receive more consistent attention across geographical contexts. Finally, “External environment” was reported for 29 variables (22 developing, 7 developed), underscoring the contextual importance linked to shaping innovation adoption, less significant in developed countries than developing ones.

The intrinsic factors were the second most investigated group in the innovation adoption research field, totaling 91 assignments. As with extrinsic factors, their presence was more pronounced in studies from developing countries than from developed ones. As a result, breakdown of the three categories included in this group reveals that “Attitudes” was the most frequently cited category ( $n = 48$ ), including 30 mentions from developing countries and 18 from developed ones. This distribution suggests that individual intentions, motivation, subjective norms, and perceived behavioural control play a central role in the adoption process across both contexts. “Perceptions” followed with 34 occurrences, but these were heavily concentrated in developing countries ( $n = 28$  vs. 6), indicating a stronger focus on subjective evaluations and expected outcomes in those settings. This pattern reflects the relevance of individual interpretation processes in contexts where uncertainty, previous experience, and perceived value of innovations shape adoption choices. Finally, “Knowledge” was the least frequently cited category within intrinsic factors ( $n = 9$ ), with 6 mentions in developing countries and only 3 in developed contexts. Despite its conceptual relevance to the innovation adoption process, variables related to knowledge appeared less frequently in the reviewed studies, making it one of the least represented categories overall.

Concluding the overall findings, the intervening variables referring to communication and support mechanisms were the least cited among the three main typologies, with a total score of 27. As with the other categories, most references originated from studies conducted in developing countries ( $n = 19$ ), while only 8 were from developed contexts. This internal distribution reflects the emphasis on the role of support and facilitating mechanisms in contexts where structural barriers and informational asymmetries are more prominent. The lower frequency of intervening factors compared to extrinsic and intrinsic variables may be attributable to the fact that these mechanisms are often presented as enabling conditions rather than analyzed as determinants of adoption. Nonetheless, their presence across both settings highlights the importance of facilitation processes that bridge external conditions and internal dispositions in influencing adoption behaviour.

This categorization underscores the complex nature of innovation adoption, emphasizing the interplay between structural conditions, individual dispositions, and support mechanisms, each shaped by their specific context. To enhance the understanding of how these dimensions are represented in the reviewed literature, the following section presents an in-depth analysis of the categories of influencing factors identified across the 57 studies included in this qualitative synthesis. The data reflect the relative frequency with which each variable, identified as influencing innovation adoption, was classified and cited in relative subcategory, providing an overview of their respective weight within the reference base. The internal composition of both groups of intrinsic and extrinsic factors is illustrated in four pie charts (Figure 9), which show the proportional distribution of own subcategories. Among extrinsic factors (Figure 9a–c), socioeconomic characteristics (44%, score of 19) for “Farmer characteristics” stand out as the most frequently studied elements, while “Status characteristics” (2%, score of 1), “Familiarity with technology” and “Personality characteristics” (5%, score of 2 each) were those less investigated in adoption uptake field. In “Innovation characteristics” influencing factors concerning technical and functional aspects of technology or practice examined in each study (41%, score of 14) were the first group for frequency, even if the distribution is fairly balanced. Finally, factors related to political governance (38%, score of 11) and geographical settings (35%, score of 10) in “External environment” category were most emphasized. This distribution of extrinsic variables highlights the relevance of individual conditions and spatial context in agri-food innovation adoption studies. In contrast, the distribution of intrinsic factors, with 93 records distributed across three psychological dimensions (Figure 9d), points to a strong emphasis on psychological and cognitive dimensions, to the disadvantage of “Knowledge” rarely considered. Attitudes account for nearly half of all intrinsic references (53%, score of 48), followed by perceptions (37%, score of 34), while the aspect of knowledge remains markedly underrepresented (10%, score of 9). This imbalance suggests a prevailing research focus on behavioural intentions and subjective evaluations, such as perceived usefulness, ease of use, and risk, rather than on investigating informational or technical training in the literature on innovation adoption.

The following section delves deeper into both categories with thematic interpretations and selected examples from the reviewed literature explaining the extracted factors affecting innovation adoption with a score greater than or equal to 10 (Table 4) because of more representative. Afterwards, with the same rigorous approach was examined how the role of communication and support mechanisms contributed to the decision process in agri-food sector.



**Figure 9.** Distribution of the number of identified factors influencing innovation adoption for subcategory (a) “Farmer characteristics”; (b) “Innovation characteristics”; (c) “External environment” included in “Extrinsic factors”. (d) “Intrinsic factors” with relative subcategories. Source: own elaboration.

#### Extrinsic Factors Contributing to the Innovation Adoption Process

The internal analysis of “Farmer characteristics” as extrinsic factors revealed 19 cited socioeconomic characteristics influencing farmers’ and stakeholders’ propensity to adopt innovations, with a marked predominance of evidence from developing countries compared to developed ones. Economic resources and financial capacity emerged as the most prominent dimension affecting innovation adoption, with financial constraints representing a critical determinant, particularly in developing country contexts. Access to credit was identified across multiple developing country studies examining different technologies, with Jena and Tanti [45] and Kumar et al. [61] demonstrating its significance for agricultural machinery adoption and improved production practices respectively, while lack of financial resources appeared as a barrier to climate-smart innovations, particularly by smallholder farmers [62]. Income levels showed distinct patterns across geographical contexts, with developing countries emphasizing their influence on farmers’ willingness to pay in circular bio-economy initiatives and to predict farmers’ innovativeness [63,64], while developed nations demonstrated income as an enabling factor for digital technology adoption alongside acreage and demographic variables [33]. According to Alemu et al. [56], the adoption of agricultural innovations was negatively correlated with poorer households and positively correlated with having larger landholdings and households, highlighting economic vulnerability as a fundamental adoption constraint.

Structural characteristics, as farm size, emerged as single or associated determinants to others across both geographical contexts and innovation types, with developing countries showing farm size relevance for green production technologies, ERP systems, and climate-smart innovations [19,34,65], while developed nations emphasized them for innovative contract solutions adoption [66]. Moreover, resource endowments represented a

determinant for developing countries, demonstrating to influence farmer-led irrigation [67], conservation agriculture [37,40] adoption, while it enabled diversification strategies across multiple agricultural domains [59]. The integration of farm size with financial resources was particularly evident in developing country contexts, where Gil et al. [68] showed farm size operating alongside financial resources for integrated crop-livestock-forestry systems and in that developed where Drewry et al. [33] investigated digital technology adoption, suggesting generational differences in technological familiarity complement formal educational attainment for advanced agricultural technologies. Educational aspect indeed demonstrated positive associations with innovation adoption across diverse geographical and technological contexts, with developing countries showing farmer education relevance for green production technologies and conservation agriculture [41,65], but it seems not to influence their innovativeness [64], while in developed nations emphasized higher education requirements for innovative contract solutions adoption [66]. The educational dimension appeared particularly pronounced in developed country contexts where advanced educational attainment enabled navigation of sophisticated institutional innovations, contrasting with developing countries where basic educational levels facilitated understanding of sustainable agricultural practices.

The second most crucial aspect in this analysis is “Social network”, revealed 10 belonging to this category influencing farmers’ propensity to adopt innovations, with an unbalanced representation across developing (7 studies) and developed countries (3 studies). Organizational membership, in fact, emerged as the most significant dimension affecting innovation adoption in manner geographically transversal. According to D’Alberto et al. [66], due to the indirect information about the farmer’s network, membership in an organization is a significant factor in determining acceptability. Specifically, cooperative membership form represented an important determinant, demonstrating to be a driver across multiple innovation adoption types, including improved technologies, sustainable management practices and some organizational innovations (e.g., [45,49,61,65]). Hermans et al. [40] state that additionally broader social dynamics, including acceptability and group dynamics, play an important role in the farmer decision-making process influencing conservation agriculture adoption in Malawi [40], while integrated crop-livestock-forestry systems adoption, in the work of Gil et al. [68], demonstrated positive associations with higher social participation and interconnectedness through social networks in Brazil. In contrast, developed country, represented by Europe, where clearly this pattern is very sensitive, organizational membership manifested through different pathways, with membership in organizations serving as important drivers of acceptability for innovative contract solutions through enhanced information networks [66], and direct involvement in agricultural advisory services influencing decision-making processes for digital fertilizer application tools [23]. The collaborative dimension in developed nations is also represented by cooperation among local different actors of value chain in Martens et al. [57], where this innovation enabled the establishment of alternative food networks through local food stores with regional products, suggesting that network based social capital facilitates a sustainable transformation of the regional agri-food system. Gender mediated network influences emerged as a limited characteristic in developing countries, represented by a single study examining wives’ influence on husband-controlled plots affecting drought-tolerant maize adoption [50], highlighting the role of intra-household social dimensions in innovation decision-making processes.

The internal analysis of “Innovation characteristics” as extrinsic factors revealed the most significant factors as belonging to technical and functional aspects linked to own innovation (14 cited factors). These variables influence farmers’ and stakeholders’ propensity to adopt innovations, and they are characterised by a predominant representation from developing countries (9 studies) compared to developed ones (5 studies). Complexity emerged

as the most significant dimension affecting innovation adoption, demonstrating negative associations with adoption in developing countries, where low complexity levels facilitated sustainable practices as conservation agriculture and system of rice intensification adoption, while high complexity represented barriers for the uptake of enterprise resource planning technology and a free, government-funded remote-sensing service [34,37,58,69]. This pattern contrasted with developed countries, where complexity manifested through integration and interoperability challenges with existing technologies for smart glasses applications [30], and software system compatibility difficulties for various digital technology adoption [33]. Compatibility and usability characteristics influence developing countries' farmers, emphasizing how technical compatibility drives farmer decisions in relation to adoption and dis-adoption for different sustainable technology and practices [34,58,69,70]. In contrast, developed nations as Europe and North America, focused on software system integration requirements [30], data utilization difficulties, and speed dissatisfaction for implementation of precision agriculture technologies [33].

Operational requirements and design features represented determinants in developing countries, where adoption was influenced by labour requirements [43], automation capabilities for agriculture 4.0 implementation [25], and modular design features [58], alongside technology unavailability barriers for climate-smart agricultural innovations [62]. In contrast, developed countries emphasized technological advances for sustainable development of food systems [71], commercial orientation for eco-innovation adoption [72], and resource constraints negatively affecting data collection capabilities for precision agriculture applications [32]. These results suggest that innovation characteristics in developed contexts prioritize technological aspects driven by the market, while developing countries focus on operational accessibility as the primary determinant for innovation adoption.

The analysis of factors concerning innovation benefits revealed 11 distinct cited benefits influencing farmers' propensity to adopt. Relative advantage emerged as the most prominent dimension affecting innovation adoption in developing countries (4 studies), where it facilitated different sustainable practices [34,37,69,70], demonstrating a positive association between them. Economic benefits represented strategic determinants across both geographical contexts, with developing countries emphasizing cash and labor-saving potential for agroforestry innovations [42] and climate-smart agriculture [62], while developed nations focused on farm performance improvements for precision agriculture [28]. Environmental sustainability benefits are geographically transversal, with developing countries highlighting ecological benefits for improved forage technologies [73]. On the other hand, in developed countries, environmental advantages facilitated the adoption of circular technologies, precision agriculture and enabled product differentiation through sustainability labels such as Fairtrade by accessing niche markets for sustainable products, enabling innovation adoption [28,53,71,74].

The internal analysis of External environment characteristics as extrinsic factors identified political governance as a critical dimension affecting innovation adoption, with 11 cited factors across 11 studies. These variables demonstrate how governmental structures, policies, and institutional frameworks influence the decision-making process to adopt a new practice. Also, this category was characterized by an unbalanced representation between developing countries (8 studies) and developed countries (2 studies), with Sharma et al. [21] covering both contexts, comparing in his study four different economies: Asia, Europe, Middle East and North America. Governance frameworks and policies emerged as the most significant dimension, showing how formal governmental structures and policy instruments influence adoption decisions. In developing countries, in fact, local government programs and policies influenced farmers' preferences for both climate smart agriculture practices [46] and improved forage technologies [73] by regional-level, and agro-environmental regula-

tions influenced green fertilizer technology [70]. While Sharma et al. [21] identified that national policies are the most important enabler of blockchain technology adoption in the agriculture supply chain both across developed and developing context, robust institutional system support through stable agricultural policies is recommended for conservation agriculture promotion [36]. In developed countries, this topic is less explored, with only one study set in North America, where economic and socio-political structural barriers created obstacles by regime level for circular technologies adoption in food systems [71]. Institutional support systems influenced adoption through 3 factors related to direct operational and financial mechanisms. Developing countries demonstrated specific patterns where financial incentives targeted low-income farmers for agriculture 4.0 implementation [25], the ability to get sustainable coffee production certification could support climate smart agriculture adoption [46], and management of irrigation schemes at the institutional level plays a significant role in technology uptake decisions [58]. In contrast, developed countries focused on multi-stakeholder institutional pressure, where non-governmental organization involvement, government training programs, and policy campaigns collectively influenced to adopt sustainability innovations through comprehensive knowledge transfer and incentive mechanisms [53].

The analysis of external environment factors related to geographical settings revealed 10 cited factors across 10 studies that consider it a fundamental dimension affecting the adoption of some typology of innovation. These variables demonstrate how physical environment, spatial characteristics, and location-specific conditions influence to adopt innovations, characterized by a predominant representation from developing countries (8 studies) compared to developed countries (2 studies), both represented by Europe [57,75]. Environmental and climatic conditions constitute the mechanism through which geographical settings influence adoption decisions regarding sustainable management practices and technical and organizational innovations that are linked to the territory, with no involvement of digital tools or precision agriculture. The farmers' preferences were shaped by the agricultural system profile and agroecological conditions for climate smart agriculture [46], while agro-ecological characteristics for conservation agriculture uptake [40]. Climate-related constraints, including droughts and water restrictions, drove the adoption of irrigation technologies [58], whereas the adoption of improved forage technologies and agricultural machinery was influenced by unsuitable climatic conditions along with exposure to climatic shocks and crop loss [45,73]; in the case of agricultural machinery, adoption decisions were also shaped by plot-specific characteristics [45]. Additionally, resource availability within geographical contexts, particularly labour availability, affected integrated crop-livestock-forestry systems adoption [68]. Land use patterns and spatial positioning reveal how territorial characteristics influence the diversity of contexts in which innovation adoption takes place. In the two European studies, geographic determinants were shown to influence the social innovation capacity of local public and private actors in establishing alternative food networks [57], and a set of dynamic drivers for managing innovation capability was identified related to the internal and external environment of companies, highlighting how spatial positioning shapes innovation opportunities [75] in the agri-food sector.

#### Intrinsic Factors Contributing to the Innovation Adoption Process

The analysis of studies focusing on "Attitudes" as intrinsic factors has emerged as a significant component of innovation adoption research, identifying 48 distinct attitudinal factors across 31 studies. These studies recognised attitudinal dimensions as determinants of innovation adoption, representing cognitive orientations and evaluative predispositions that explain the intrinsic decision-making process. More specifically, these variables exam-

ine how farmers' and stakeholders' cognitive orientations, behavioural predispositions, and value systems influence their propensity to adopt innovations, with representation from both developing countries (18 studies) and developed countries (13 studies). Environmental attitudes and ecological concerns emerged across both geographical contexts. In developing countries, environmental attitudes for a new ecological paradigm drove for example circular bio-economy initiatives [63] and green fertilizer technology adoption [70]. Similarly, developed countries demonstrated environmental orientations through pro-environment attitudes in innovative contract solutions [66], and ecological concerns in favour of novel crop adoption [74] to provide multiple ecosystem services. Environmental corporate culture was identified as a determinant factor in eco-innovation adoption [72], indicating that environmental consciousness operates at both individual and organizational levels. Risk aversion and management represented another significant variable, particularly prominent in developing countries. Risk aversion was explicitly identified as an adoption factor in conservation agriculture contexts [39,40], while risk management capacity and ability to cope with uncertainties and risks showed positive correlation with farmers' willingness to experiment with new techniques and innovate [59,68]. Trust-related attitudes manifested across both geographical contexts, demonstrating general importance in adoption processes. Bechtet [23] states that trust between European adopters and their advisors was the reason for which they considered adopting digital innovation, serving as a fundamental prerequisite for technology acceptance, while Hermans et al. [40] recognize in the trust in information sources influenced conservation agriculture adoption in Sub-Saharan Africa. However, in the absence of advisors' offers, considered a crucial prerequisite for adoption farmers by Bechtet [23], farmers do not adopt the tool even if they are well informed about it. Group and subjective norms also demonstrated significant influence on adoption decisions in both country context. Group norms and social pressure were identified as affected factors in different sustainable innovation adoption [53,70,73,76,77] through collective and peer-based mechanisms. Normative beliefs, alongside behavioural and control beliefs, were recognized as determinants in aquafeed innovation adoption [66,76,77], suggesting that social conformity and peer influence constitute important attitudinal dimensions in adoption processes concerning both sustainable and organizational innovations.

Studies focusing on attitudinal factors constituted a substantial component of the reviewed literature, with 34 factors related to perception identified across 21 distinct studies. These papers recognised attitudinal dimensions as determinants of innovation adoption, including cognitive orientations and evaluative predispositions that explain decision-making processes. The geographic distribution demonstrated representation from both developing countries (16 studies) and developed countries (5 studies), showing substantial consistency with the geographic distribution of the dataset.

Technology perception emerged as the most prevalent attitudinal dimension, with perceived usefulness and perceived ease of use documented across multiple innovation contexts and geographic settings. Farmers' evaluation of digital technologies consistently caught specific perception patterns in developing context: perceived usefulness and ease of use were identified, for example, in microdosing technology [78], and IoT platforms [29]. Similarly, government-funded irrigation scheduling technology in Africa revealed that perceived accuracy, affordability, and particularly easy-to-use computer interfaces providing continuous management advice served as key uptake drivers [58]. In addition, agricultural advice applications demonstrated performance expectancy effects [31], while farmers' perceptions about technology attributes and effectiveness influenced climate-smart technology adoption [19]. On the other hand, in developed countries, smart glasses technology adoption was affected by perceived benefit and compatibility [30], and precision agriculture contexts revealed value perception by growers and consultants [32].

Risk perception manifested as a significant attitudinal factor across both geographical contexts, in particular concerning consequences and beliefs about climate change effects. Developing countries demonstrated production-focused risk perception influencing climate-smart agriculture technologies in Latin America [49], eco-innovation through better cotton adoption in Asia [79], and drought-tolerant maize adoption in Sub-Saharan Africa [50]. Whereas developed countries showed risk perception through tangible climate change consequences on crops. For instance in Hungary, an exploratory factor analysis revealed that farmers' perceptions of climate change consequences on agricultural crops significantly influenced adoption of innovative mitigation practices (including new varieties, ice and frost protection, and the use of agro-meteorological data), because of perceived harm from pests, pathogens and illnesses demonstrating substantial impact on new variety adoption, while water damage concerns affected frost protection adoption [44].

Perceived benefits and relative advantage constitute a consistently reported driver of innovation uptake, especially in developing countries. Numerous studies on different typology of technologies and practices [19,70,77,80] conducted in these contexts highlight this factor, while also recording economic benefit skepticism [80] and trade-off evaluations that include intangible social costs [40]. Similarly, in Europe, evaluation of perceived benefits likewise emerged as fundamental for both digital and sustainability innovations. Agricultural stakeholders' acceptance of smart glasses for on-farm use was directly shaped by the perceived value of the device benefit [30]. In the horticultural sector, adoption of sustainability innovations was motivated by clear advantages such as reduced energy expenditure, compliance with retailer standards, risk mitigation, and opportunities for product differentiation through certification schemes [53]. In the horticultural sector, adoption of sustainability innovations was motivated by clear advantages such as energy cost reduction, compliance with retailer standards, risk mitigation, and opportunities for product differentiation through certification [53]. Benefit evaluation therefore represents a core cognitive process in adoption decisions. In Lao PDR, analysis of four technologies (direct seeding, improved fertilizers, white-rice cultivation for international markets, and cattle vaccination) showed that adoption dropped markedly when additional production costs were not matched by visible profits. While, entrepreneurs, by contrast, judged the same practices less difficult and more affordable when they recognised a positive recompense [81].

Transitioning from utilitarian assessments to constructs value laden, the current literature shows that adoption decisions are embedded in beliefs, values, and social identity. Ecological identity illustrates this evidence, showing a higher propensity of organic farmers in Europe to enroll in value chain and result-based contracts' adoption, underscoring the role of ecological identity in contractual acceptability [66]. Similarly, cultural orientation and personal innovativeness further shape uptake. Early adopters of integrated crop-livestock-forestry systems exhibit, in fact, higher social participation and openness to change in Latin America [68], while food growers with strong innovative traits are more likely to implement precision agriculture tools in Asia [26]. Therefore, Asian traditionalist farmers reached lower peak adoption rates than entrepreneur-oriented peers when practices involved additional production costs, perhaps without perceiving any benefit [81]. Moreover, trust and advisory relationships prove equally influential in the uptake process. Indeed, in Europe, decision support tools were adopted almost exclusively when promoted by trusted advisors (either a cooperative, the Chamber of Agriculture, or dealers selling the innovation), indicating that trust between farmers and advisors, thus appears to be a crucial lever for digital technologies [23].

Finally, cognitive competencies emerged as particularly underrepresented determinants with nine extracted factors from eight studies, examining this dimension as adoption

enabling factor. Of these studies, three examined precision agriculture and alternative food networks in developed country contexts [32,57,82], while five focused on different sustainable innovations in developing countries [34,46,62,68,79]. Technical expertise and understanding constituted an important element both to contribute uptake of sustainable innovation in developing countries [34,68], and especially to guarantee digitalization across developed countries [32,82]. Beyond technical competencies, climate adaptation skills emerge as a specialized constraint within climate-smart agricultural technological innovations, facing implementation barriers related to climate change management skills, and knowledge acquisition and use processes, compounded by limited technology access awareness across developing countries [46,62]. Complementing these findings, Zulfikar and Thapa [83] confirm that information access provided by formal organizations a favorable impact on the innovation adoption intensity, suggesting that institutional learning modalities influence adoption readiness.

#### The Role of Communication and Extension as Factors Intervening to Innovation Adoption Process

Communication and extension emerged as critical intervening factors influencing innovation adoption across diverse agricultural contexts, with 27 pieces of evidence from reviewed papers setting both developed and developing countries. The analysis revealed distinct patterns in how communication channels and extension services facilitate technology adoption, with particular emphasis on collaborative approaches and institutional support mechanisms.

Training programs and information dissemination from authoritative sources represented the most frequently cited communication factors, appearing across multiple innovation types and geographical contexts. In developing countries, the formal training programs, indeed, proved essential for eco-innovation and conservation agriculture adoption [20,41,79,83], demonstrating that wider participation of sustainable practices can be positively affecting by institutional support for organizing training programs, providing credit facilities, and delivering information of technologies. Specifically, it emerged the importance to reduce vulnerability through tailored training approaches in developing countries, where tailor-made training programs can be explored to ensure that each gender is targeted via the most appropriate pathway based on its accessibility [19]. In the other hand, in developed countries, intervening factors focused on sophisticated technology requirements to implement digital tools in favour of agricultural innovation systems, where farmers manifested needs for more specialized education and training regarding sophisticated technology [27,32,33]. In this context, the development of collaborative networks supported by institutional partnerships transversely emerged as a fundamental cooperative mechanism, with evidence presenting the evolution from traditional advisory relationships to complex multi-stakeholder platforms. In developed countries, the role of collaboration and its importance is evident when in Europe working in networks (public, private, sectoral or cross-sectoral), connecting different stakeholders as farmers, universities, administrators, and distributors, in order to be able to face the innovation adoption project [28]. This value is evident across advisory organizations (cooperatives, Chambers of Agriculture, trading companies), who serve as network anchors. Indeed, digital innovation adoption is triggered by an offer that farmers directly receive from advisory organizations function in the farming sector as the main advisory suppliers that farmers turn to during the process of adopting the innovation, highlighting the importance of trust relationships within collaborative networks [23]. Moreover, this collaborative approach extended to cooperative systems where cooperation with farmers, consumers, and institutions enabled shared infrastructure, food production and processing methods as well as agricultural know-how [55], demonstrating how new forms of cooperation in relation to the establish-

ment of local food supply can ensure the sustainability of small-scale farming contributing to facilitate both knowledge transfer and resource sharing. In developing countries, the institutional landscape emphasized broader stakeholder integration, with smallholder centred stakeholder collaboration mode and tailored strategies, examining multi-stakeholder platforms better connecting smallholders, scientists, government, and industry [43]. In this context, the collaborative dimension encompassed social network strengthening, with emphasis on strengthening social interactions within the farming community and with other territorial stakeholders and the value chains [59]. Therefore, supporting institutions played fundamental roles within these networks, with promoting institutions facilitating sustainable innovation adoption [20,36,73] and research centres as a source of agricultural information serving as network nodes [50]. In this regard it was demonstrated by Kumar et al. [61] that diversity of information sources influenced adoption patterns, for instance when Asian farmers' sources of information affected the probability of the adoption of improved practices, with increased adoption when farmers obtained information from informal sources, cooperatives organizations, and public and private extension programs.

#### 4. Discussion

This systematic review identified growing academic interest concerning innovation adoption in agricultural and agrifood sectors worldwide. Research intensity culminated in recent years, reflecting heightened scholarly attention driven by major sustainability policy frameworks such as the European Green Deal, the Farm to Fork and Sustainable Development Goals Strategies. This temporal concentration aligns with global recognition of agricultural innovation's critical role in addressing climate change and food security challenges [84]. However, it contrasts with earlier periods where innovation research appears more geographically dispersed across country dimensions. The geographical distribution suggests, despite the global relevance of innovation uptake in agrifood, a predominant focus on developing contexts, consistent with substantial funding investments (ranging from \$50 to \$70 billion per year in 2019 US dollars for the Global South) for agricultural transformation, indicated in the study of Prasad et al. [85]. This concentration reflects the strategic importance of agricultural innovation adoption in regions facing significant sustainability challenges and food security pressures. Contemporary innovation research seems shifted toward contexts facing greater structural constraints and institutional complexities, for instance, focusing on digital transformation in developing countries' agricultural sectors [86]. This geographical focus provides valuable insights into innovation adoption under resource constraints while highlighting opportunities for comparative research approaches across diverse institutional contexts.

The cross-dimensional analysis of innovations reveals the complexity of innovations investigated from multiple perspectives that extend beyond geographical patterns. This finding confirms Cooper's [4] theoretical approach regarding the multidimensional nature of innovation adoption. Precision agriculture and decision support technologies emerged as crucial cross-dimensional innovations. These demonstrate how digitalization creates pathways for sustainable agricultural transformation [87]. Contemporary digital innovations facilitate farmer adoption and knowledge diffusion while simultaneously contributing to environmental impact minimization and productivity enhancement. This illustrates the convergence of sustainability and efficiency objectives characteristic of agriculture 4.0 implementation, where innovation serves as a facilitator of digital transformation by addressing behavioral intention to adopt technological solutions that integrate food security awareness with innovation characteristics [86]. Conservation agriculture systems and sustainable management practices dominated multiple ecological categories, particularly soil and water conservation and biodiversity preservation. They demonstrate that

productivity and environmental benefits can be achieved simultaneously through integrated approaches. Climate-smart agriculture innovations improved resilience to climate change through integrated adaptation and mitigation strategies while providing empirical evidence for interconnected economic benefits in agricultural systems [88].

Collaboration emerged as a transversal key element in agrifood innovation adoption. It manifests both as an innovation tool (e.g., innovative contract solutions, innovation networks, cooperative systems) and a facilitator for implementing technical and organizational innovations. This finding highlights how collaborative mechanisms enable digital and sustainable transformations while addressing behavioral and cultural dimensions of technology adoption overcoming resistance to change, and bridging the digital divide, as recommended by the European Commission [89]. Collaboration functions not merely as a supportive mechanism but as an integral component of innovation design and implementation. Multi-stakeholder collaboration innovations emphasize the necessity of institutional support for digital transformation [90]. These include blockchain technology, IoT platforms, and enterprise resource planning systems. Blockchain-based frameworks particularly enhance data integrity, trust, and operational efficiency through immutable ledgers and smart contracts while supporting transparency, traceability, and security across food supply chains [91,92]. Organizational innovations represent another crucial collaborative dimension. They include stakeholder interaction models and public-private collaboration frameworks designed to foster sustainable transformation. Innovation network systems ensure fair representation of farmer diversity in innovation processes [93], addressing critiques of top-down innovation approaches that have historically marginalized smallholder perspectives while establishing institutional frameworks that support coordinated technology implementation across value chains.

The framework focused on purposes revealed distinct patterns in research focus across sustainability dimensions. Ecological purpose innovations dominate contemporary literature, demonstrating the sector's emphasis on environmental sustainability. The emphasis on reducing externalities reflects growing awareness of agriculture's environmental footprint and the need for mitigation strategies. However, limited attention to biodiversity preservation compared to climate-smart agriculture suggests selective environmental priorities. These may not adequately address the full spectrum of ecological challenges facing agricultural systems.

Economic purpose innovations showed balanced distribution across productivity optimization and economic viability dimensions, in line with the study of Belamkar et al. [94], who explained the dual focus on productivity and yield improvement in agri-food sector. However, minimal attention to rural livelihoods compared to productivity gains suggests that research priorities may not fully align with broader development objectives emphasizing poverty reduction and social equity.

Social purpose innovations demonstrated concentrated focus on farmer adoption and knowledge diffusion. This confirms the central emphasis of included studies while revealing significant gaps in cultural acceptance, gender, and inclusivity considerations. The concentration contrasts with food systems' transformation approaches that emphasize multidimensional social outcomes as the need for a stronger gender lens [95]. The minimal focus on cultural acceptance and gender dimensions indicates insufficient attention to social equity and inclusivity in innovation processes. This persists despite growing recognition of their importance in sustainable development frameworks and critiques of technology-centred approaches that ignore social differentiation. Contemporary approaches to digital technology introduction in agrifood systems often fail to address key aspects of inclusion, with inclusive innovation mechanisms focusing on beneficiary involvement in innovation processes without elucidating how to operationalize deeper inclusivity that accounts for

the nature of engagement and relationship dynamics required for successful outcomes. Institutional purpose represented the least explored dimension. This underscores insufficient integration of governance and institutional aspects in current innovation adoption research [96].

The structured categorization of adoption factors revealed a complexity overview in interactions between structural conditions, individual orientations, and institutional supports in stakeholder decision-making process. This extends previous theoretical frameworks that examined these dimensions in isolation while questioning linear models of technology adoption. Extrinsic factors emerged as most frequently examined, with a predominant focus in developing countries reflecting emphasis on structural and contextual constraints. Intrinsic factors demonstrated notable geographical patterns, with developed countries showing balanced interest between internal and external determinants compared to developing contexts. This distribution might reflect the presence of more stable institutional environments where psychological and cognitive dimensions gain relative prominence compared to contexts characterized by greater external constraints [97], in contrast with the universal applicability of psychological adoption models. The dominance of attitudes within intrinsic factors confirms the central role of psychological determinants across contexts, supporting established theoretical frameworks such as the Theory of Planned Behavior by Ajzen [98]. Environmental attitudes consistently facilitated uptake of sustainability oriented innovations across contexts, supporting theoretical frameworks emphasizing value-belief-norm relationships in pro-environmental behavior [99] while providing empirical evidence for the integration of environmental and economic motivations in agricultural decision-making.

Social networks played differentiated roles across settings. This extends understanding of social influence mechanisms beyond traditional peer effects to include institutional and value chain networks. Cooperative membership emerged as both informational catalyst and mechanism facilitating access to key technologies, as supported by Nakano et al. [100]. This challenges individualistic approaches to adoption while supporting collective action approaches, facilitating information exchange among members, promoting mutual learning and sharing experiences [101]. However, these variables' influence is frequently mediated by internal factors such as perceived usefulness and risk evaluation. This supports recent theoretical developments emphasizing the interaction between individual decision-making process and external influences in agricultural adoption models [102]. Therefore, finding questions linear diffusion models and supports more complex theoretical frameworks that recognize feedback loops and dynamic interactions between social and individual factors.

Intervening factors, focusing on communication and extension mechanisms, demonstrated predominant concentration in developing countries. This reflects emphasis on support mechanisms in contexts where structural barriers and informational asymmetries are more prominent. The distribution aligns with theoretical frameworks emphasizing the role of extension systems in bridging knowledge gaps and facilitating technology transfer [103]. The relatively lower attention to intervening factors compared to extrinsic and intrinsic variables suggests potential underestimation of their importance in innovation adoption research. Communication and extension factors serve as crucial mediators between innovation characteristics and adoption decisions, facilitating knowledge transfer, capacity building, and institutional coordination. They support theoretical frameworks that emphasize the importance of innovation systems approaches [104–106] and provide empirical evidence for the active role of institutional intermediaries in shaping adoption outcomes.

## 5. Conclusions

This systematic literature review, focusing on various types of innovations in agriculture and food systems, reveals that different innovations work differently. In addition, the adoption success greatly depends on the specific contexts in terms of local culture, geography, and agri-food business organization. For that reason, innovation adoption must be tailored to fit different cases, which are influenced by multiple factors: (i) extrinsic factors such as policies, market conditions, and climate; (ii) intrinsic factors like farmers' knowledge, attitudes, and resources; and (iii) intervening factors such as training, creating networks, and infrastructure. Moreover, our study underlines that these determinants are interconnected, and collaboration between stakeholders (i.e., farmers, researchers, businesses, and policymakers) is essential for innovation adoption to succeed. In fact, collaboration appears as a tool (i.e., partnerships leading to better solutions) and a facilitator (i.e., networking inducing spread knowledge). Furthermore, policies and innovation programs must adapt to local needs, avoiding generic solutions, learning from worldwide research for customizing approaches for each target area, and allowing for adjustments based on different regions' challenges, where farmers and local stakeholders have their voice in innovation planning for sustainable and climate-resilient farming.

## 6. Implications, Limitations and Future Directions

The key findings of this research show that most innovations focus on environmental objectives, but social and institutional aspects (like community needs and governance) are often ignored. In addition, successful adoption of innovations requires addressing three things: external barriers (e.g., costs), internal motivations (e.g., farmer interests), and support systems (e.g., training). In fact, a participatory approach, including all concerned stakeholders and social, ecological, and cultural aspects within a value chain, is essential for innovations to succeed. With respect to the limitations, the research only approached English-language research from two databases, missing some important unpublished or non-English work. Also, we focused our literature review on recent studies (2014–2025), excluding older but maybe relevant references. These choices helped keep the study focused but may have limited the full picture of innovation. From this perspective, future research is needed on how innovations fit into community values and structures. Methods should combine insights from psychology, economics, and governance to better understand adoption challenges.

**Supplementary Materials:** The following supporting information can be downloaded at: <https://www.mdpi.com/article/10.3390/agriculture15171845/s1>, Supplementary Material: Table S1: PRISMA 2020 Checklist, Supplementary Material: Table S2: Studies included in review. This table provides key information on the 80 studies analyzed in the systematic review.

**Author Contributions:** Conceptualization, A.A.C., M.F., and A.P.; methodology, A.A.C. and M.F.; software, A.A.C.; validation, A.P.; formal analysis, A.A.C.; investigation, A.A.C. and M.F.; resources, F.B.; data curation, A.A.C. and G.T.; writing—original draft preparation, A.A.C.; writing—review and editing, A.P. and M.F.; visualization, A.A.C.; supervision, F.B.; project administration, F.B.; funding acquisition, F.B. All authors have read and agreed to the published version of the manuscript.

**Funding:** This work was carried out within the Agritech National Research Center and received funding from the European Union Next-Generation EU (Piano Nazionale di Ripresa e Resilienza (PNRR) Mission 4 Component 2, Investment 1.4-d.d. 1032 17/06/2022, cn00000022). The PhD scholarship of A.A.C. was funded with funds from the PNRR, Mission 4 Component 2 “From Research to Enterprise”—Investment 3.3 “Introduction of innovative doctorates that respond to the innovation needs of companies and promote the recruitment of researchers from companies”. This manuscript reflects only the authors' views and opinions; neither the European Union nor the European Commission can be considered responsible for them.

**Institutional Review Board Statement:** Not applicable. This manuscript does not involve humans or animals.

**Data Availability Statement:** Data will be made available on request.

**Acknowledgments:** We utilized an AI-powered language tool, OpenAI's ChatGPT, 4.5 version, to enhance the clarity and readability of this manuscript while ensuring the integrity of the original content. The authors reviewed the results and take full responsibility for the final content.

**Conflicts of Interest:** Author Michel Frem was employed by the company SINAGRI srl. Author Giovanni Tricarico was employed by the company Confcooperative Puglia. The remaining authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

## References

1. FAO. *World Food and Agriculture—Statistical Yearbook 2024*; FAO: Rome, Italy, 2024; ISBN 978-92-5-139255-3.
2. EU to Invest More than €760 Million in Digital Transition and Cybersecurity. Available online: <https://digital-strategy.ec.europa.eu/en/news/eu-invest-more-eu760-million-digital-transition-and-cybersecurity> (accessed on 27 July 2025).
3. Barrett, C.B.; Reardon, T.; Swinnen, J.; Zilberman, D. Agri-Food Value Chain Revolutions in Low- and Middle-Income Countries. *J. Econ. Lit.* **2022**, *60*, 1316–1377. [\[CrossRef\]](#)
4. Cooper, J.R. A Multidimensional Approach to the Adoption of Innovation. *Manag. Decis.* **1998**, *36*, 493–502. [\[CrossRef\]](#)
5. Meijer, S.S.; Catacutan, D.; Ajayi, O.C.; Sileshi, G.W.; Nieuwenhuis, M. The Role of Knowledge, Attitudes and Perceptions in the Uptake of Agricultural and Agroforestry Innovations among Smallholder Farmers in Sub-Saharan Africa. *Int. J. Agric. Sustain.* **2015**, *13*, 40–54. [\[CrossRef\]](#)
6. Pretty, J. *Agroecological Approaches to Agricultural Development*; World Bank: Washington, DC, USA, 2006.
7. OECD; Food and Agriculture Organization of the United Nations. *OECD-FAO Agricultural Outlook 2025–2034*; OECD-FAO Agricultural Outlook; OECD Publishing: Paris, France, 2025; ISBN 978-92-64-40615-5.
8. Ciric, D.; Borocki, J.; Gracanin, D.; Lalic, B. Methodologies for measuring innovation performances. In Proceedings of the 7th International Conference on Mass Customization and Personalization in Central Europe (MCP-CE 2016), Novi Sad, Serbia, 21–23 September 2016.
9. Rosário, J.; Madureira, L.; Marques, C.; Silva, R. Understanding Farmers' Adoption of Sustainable Agriculture Innovations: A Systematic Literature Review. *Agronomy* **2022**, *12*, 2879. [\[CrossRef\]](#)
10. Giua, C.; Materia, V.C.; Camanzi, L. Smart Farming Technologies Adoption: Which Factors Play a Role in the Digital Transition? *Technol. Soc.* **2022**, *68*, 101869. [\[CrossRef\]](#)
11. Vecchio, Y.; De Rosa, M.; Pauselli, G.; Masi, M.; Adinolfi, F. The Leading Role of Perception: The FACOPA Model to Comprehend Innovation Adoption. *Agric. Econ.* **2022**, *10*, 5. [\[CrossRef\]](#)
12. Rizzo, G.; Migliore, G.; Schifani, G.; Vecchio, R. Key Factors Influencing Farmers' Adoption of Sustainable Innovations: A Systematic Literature Review and Research Agenda. *Org. Agric.* **2024**, *14*, 57–84. [\[CrossRef\]](#)
13. John, D.; Hussin, N.; Shahibi, M.S.; Ahmad, M.; Hashim, H.; Ametefe, D.S. A Systematic Review on the Factors Governing Precision Agriculture Adoption among Small-Scale Farmers. *Outlook Agric.* **2023**, *52*, 469–485. [\[CrossRef\]](#)
14. Page, M.J.; McKenzie, J.E.; Bossuyt, P.M.; Boutron, I.; Hoffmann, T.C.; Mulrow, C.D.; Shamseer, L.; Tetzlaff, J.M.; Akl, E.A.; Brennan, S.E.; et al. The PRISMA 2020 Statement: An Updated Guideline for Reporting Systematic Reviews. *Int. J. Surg.* **2021**, *88*, 105906. [\[CrossRef\]](#)
15. Ofosu-Ampong, K.; Abera, W.; Müller, A.; Adjei-Nsiah, S.; Boateng, R.; Acheampong, B. Framing Behaviour Change for Sustainable Agriculture: Themes, Approaches, and Future Directions. *Farming Syst.* **2025**, *3*, 100123. [\[CrossRef\]](#)
16. El Bakali, I.; Brouziyne, Y.; Ait El Mekki, A.; Maatala, N.; Harbouze, R. The Impact of Policies on the Diffusion of Agricultural Innovations: Systematic Review on Evaluation Approaches. *Outlook Agric.* **2024**, *53*, 3–14. [\[CrossRef\]](#)
17. Birhanu, M.Y.; Bruno, J.E.; Alemayehu, T.; Esatu, W.; Geremew, K.; Yemane, T.; Kebede, F.G.; Dessie, T. Beyond Diffusion to Sustained Adoption of Innovation: A Case of Smallholder Poultry Development in Sub-Saharan Africa. *Int. J. Agric. Sustain.* **2022**, *20*, 1028–1046. [\[CrossRef\]](#)
18. Dayamba, D.S.; Ky-Dembele, C.; Bayala, J.; Dorward, P.; Clarkson, G.; Sanogo, D.; Diop Mamadou, L.; Traoré, I.; Diakité, A.; Nenkam, A.; et al. Assessment of the Use of Participatory Integrated Climate Services for Agriculture (PICSA) Approach by Farmers to Manage Climate Risk in Mali and Senegal. *Clim. Serv.* **2018**, *12*, 27–35. [\[CrossRef\]](#)
19. Murage, A.W.; Pittchar, J.O.; Midega, C.A.O.; Onyango, C.O.; Khan, Z.R. Gender Specific Perceptions and Adoption of the Climate-Smart Push-Pull Technology in Eastern Africa. *Crop Prot.* **2015**, *76*, 83–91. [\[CrossRef\]](#)

20. Ndah, H.T.; Schuler, J.; Uthes, S.; Zander, P.; Triomphe, B.; Mkomwa, S.; Corbeels, M. Adoption Potential for Conservation Agriculture in Africa: A Newly Developed Assessment Approach (QAToCA) Applied in Kenya and Tanzania. *Land Degrad. Dev.* **2015**, *26*, 133–141. [\[CrossRef\]](#)
21. Sharma, M.; Khalil, A.A.; Daim, T. Blockchain Technology Adoption: Multinational Analysis of the Agriculture Supply Chain. *IEEE Trans. Eng. Manag.* **2024**, *71*, 12400–12417. [\[CrossRef\]](#)
22. World Bank. World Bank Country Classifications by Income Level for 2024–2025. 2024. Available online: <https://blogs.worldbank.org/en/opendata/world-bank-country-classifications-by-income-level-for-2024-2025> (accessed on 14 May 2025).
23. Bechtet, N. How Do Advisory Suppliers Support Farmers in Evaluating a Digital Innovation? A Case Study on Decision Support Tools for Fertilizer Application in France. *J. Innov. Econ. Manag.* **2023**, *42*, 73–101. [\[CrossRef\]](#)
24. Meng, N.; McConnell, M.D.; Wes Burger, L., Jr. Economically Targeting Conservation Practices to Optimize Conservation and Net Revenue Using Precision Agriculture Tools. *Precis. Agric.* **2022**, *23*, 1375–1393. [\[CrossRef\]](#)
25. Alam, M.F.B.; Tushar, S.R.; Zaman, S.M.; Gonzalez, E.D.R.S.; Bari, A.B.M.M.; Karmaker, C.L. Analysis of the Drivers of Agriculture 4.0 Implementation in the Emerging Economies: Implications towards Sustainability and Food Security. *Green Technol. Sustain.* **2023**, *1*, 100021. [\[CrossRef\]](#)
26. Gwadabe, U.M.; Arumugam, N.; Amirah, N.A. Exploration and Development of Measurement Items of Innovation for New Technology Adoption among Small Farmers. *Univers. J. Agric. Res.* **2022**, *10*, 620–626. [\[CrossRef\]](#)
27. Kountios, G.; Ragkos, A.; Bournaris, T.; Papadavid, G.; Michailidis, A. Educational Needs and Perceptions of the Sustainability of Precision Agriculture: Survey Evidence from Greece. *Precis. Agric.* **2018**, *19*, 537–554. [\[CrossRef\]](#)
28. Partalidou, M.; Paltaki, A.; Lazaridou, D.; Vieri, M.; Lombardo, S.; Michailidis, A. Business Model Canvas Analysis on Greek Farms Implementing Precision Agriculture. *Agric. Econ. Rev.* **2018**, *19*, 28–45.
29. Zamil, A.M.A.; Javed, H.M.U.; Ali, S. Internet of Things Platforms Adoption in Agriculture: Comparative Theoretical Models. *Int. J. Retail. Distrib. Manag.* **2024**, *52*, 965–981. [\[CrossRef\]](#)
30. Sara, G.; Todde, G.; Pinna, D.; Caria, M. Investigating the Intention to Use Augmented Reality Technologies in Agriculture: Will Smart Glasses Be Part of the Digital Farming Revolution? *Comput. Electron. Agric.* **2024**, *224*, 109252. [\[CrossRef\]](#)
31. Molina-Maturano, J.; Verhulst, N.; Tur-Cardona, J.; Güereña, D.T.; Gardeazábal-Monsalve, A.; Govaerts, B.; Speelman, S. Understanding Smallholder Farmers’ Intention to Adopt Agricultural Apps: The Role of Mastery Approach and Innovation Hubs in Mexico. *Agronomy* **2021**, *11*, 194. [\[CrossRef\]](#)
32. Song, X.; Evans, K.J.; Bramley, R.G.V.; Kumar, S. Factors Influencing Intention to Apply Spatial Approaches to On-Farm Experimentation: Insights from the Australian Winegrape Sector. *Agron. Sustain. Dev.* **2022**, *42*, 96. [\[CrossRef\]](#)
33. Drewry, J.L.; Shutske, J.M.; Trechter, D.; Luck, B.D.; Pitman, L. Assessment of Digital Technology Adoption and Access Barriers among Crop, Dairy and Livestock Producers in Wisconsin. *Comput. Electron. Agric.* **2019**, *165*, 104960. [\[CrossRef\]](#)
34. Haberli, C., Jr.; Oliveira, T.; Yanaze, M. Understanding the Determinants of Adoption of Enterprise Resource Planning (ERP) Technology within the Agrifood Context: The Case of the Midwest of Brazil. *Int. Food Agribus. Manag. Rev.* **2017**, *20*, 729–746. [\[CrossRef\]](#)
35. Junior, C.H.; Oliveira, T.; Yanaze, M. The Adoption Stages (Evaluation, Adoption, and Routinisation) of ERP Systems with Business Analytics Functionality in the Context of Farms. *Comput. Electron. Agric.* **2019**, *156*, 334–348. [\[CrossRef\]](#)
36. Ndah, H.T.; Probst, L.; Kaweesa, S.; Kuria, P.; Mkomwa, S.; Rodrigues, P.; Basch, G.; Uckert, G.; Sieber, S.; Knierim, A.; et al. Improving Farmers’ Livelihoods through Conservation Agriculture: Options for Change Promotion in Laikipia, Kenya. *Int. J. Agric. Sustain.* **2020**, *18*, 212–231. [\[CrossRef\]](#)
37. Tama, R.A.Z.; Hoque, M.M.; Liu, Y.; Alam, M.J.; Yu, M. An Application of Partial Least Squares Structural Equation Modeling (PLS-SEM) to Examining Farmers’ Behavioral Attitude and Intention towards Conservation Agriculture in Bangladesh. *Agriculture* **2023**, *13*, 503. [\[CrossRef\]](#)
38. Ranjan, P.; Usher, E.M.; Bates, H.T.; Zimmerman, E.K.; Tyndall, J.C.; Morris, C.J.; Koontz, T.M.; Prokopy, L.S. Understanding Barriers and Opportunities for Diffusion of an Agricultural Decision-Support Tool: An Organizational Perspective. *J. Hydrol.* **2022**, *607*, 127584. [\[CrossRef\]](#)
39. Monjardino, M.; Ridaura, S.L.; Van Loon, J.; Mottaleb, K.; Kruseman, G.; Zepeda, A.; Hernández, E.O.; Burgueño, J.; Singh, R.G.; Govaerts, B.; et al. Disaggregating the Value of Conservation Agriculture to Inform Smallholder Transition to Sustainable Farming: A Mexican Case Study. *Agronomy* **2021**, *11*, 1214. [\[CrossRef\]](#)
40. Hermans, T.D.G.; Whitfield, S.; Dougill, A.J.; Thierfelder, C. Why We Should Rethink ‘Adoption’ in Agricultural Innovation: Empirical Insights from Malawi. *Land Degrad. Dev.* **2021**, *32*, 1809–1820. [\[CrossRef\]](#)
41. Muzangwa, L.; Mnkeni, P.N.S.; Chidzuza, C. Assessment of Conservation Agriculture Practices by Smallholder Farmers in the Eastern Cape Province of South Africa. *Agronomy* **2017**, *7*, 46. [\[CrossRef\]](#)
42. Amare, D.; Darr, D. Farmers’ Intentions Toward Sustained Agroforestry Adoption: An Application of the Theory of Planned Behavior. *J. Sustain. For.* **2023**, *42*, 869–886. [\[CrossRef\]](#)

43. Guo, X.; Zhu, A.L.; Zhu, X.; An, Z.; Xu, Y.; Zhuang, M.; Wang, C.; Zhang, F. Promoting Sustainable Smallholder Farming Systems in China. *Agric. Syst.* **2024**, *219*, 104035. [\[CrossRef\]](#)
44. Hamam, M.; Raimondo, M.; Spina, D.; Király, G.; Di Vita, G.; D'Amico, M.; Tóth, J. Climate Change Perception and Innovative Mitigation Practices Adopted by Hungarian Farms. *Agris-Line Pap. Econ. Inform.* **2023**, *15*, 57–72. [\[CrossRef\]](#)
45. Jena, P.R.; Tanti, P.C. Effect of Farm Machinery Adoption on Household Income and Food Security: Evidence from a Nationwide Household Survey in India. *Front. Sustain. Food Syst.* **2023**, *7*, 922038. [\[CrossRef\]](#)
46. Djufry, F.; Wulandari, S.; Villano, R. Climate Smart Agriculture Implementation on Coffee Smallholders in Indonesia and Strategy to Accelerate. *Land* **2022**, *11*, 1112. [\[CrossRef\]](#)
47. Ghimire, R.; Khatri-Chhetri, A.; Chhetri, N. Institutional Innovations for Climate Smart Agriculture: Assessment of Climate-Smart Village Approach in Nepal. *Front. Sustain. Food Syst.* **2022**, *6*, 734319. [\[CrossRef\]](#)
48. Prasad, J.V.N.S.; Loganandhan, N.; Ramesh, P.R.; Rama Rao, C.A.; Raju, B.M.K.; Rao, K.V.; Subba Rao, A.V.M.; Rejani, R.; Kundu, S.; Pankaj, P.K.; et al. Assessment of Resilience Due to Adoption of Technologies in Frequently Drought-Prone Regions of India. *Sustainability* **2024**, *16*, 7339. [\[CrossRef\]](#)
49. Rodríguez-Barillas, M.; Poortvliet, P.M.; Klerkx, L. Unraveling Farmers' Interrelated Adaptation and Mitigation Adoption Decisions under Perceived Climate Change Risks. *J. Rural. Stud.* **2024**, *109*, 103329. [\[CrossRef\]](#)
50. Fisher, M.; Carr, E.R. The Influence of Gendered Roles and Responsibilities on the Adoption of Technologies That Mitigate Drought Risk: The Case of Drought-Tolerant Maize Seed in Eastern Uganda. *Glob. Environ. Change* **2015**, *35*, 82–92. [\[CrossRef\]](#)
51. Sidibé, A.; Olabisi, L.S.; Doumbia, H.; Touré, K.; Niamba, C.A. Barriers and Enablers of the Use of Digital Technologies for Sustainable Agricultural Development and Food Security: Learning from Cases in Mali. *Elementa* **2021**, *9*, 00106. [\[CrossRef\]](#)
52. Jamil, I.; Jun, W.; Mughal, B.; Wheed, J.; Hussain, H.; Waseem, M. Agricultural Innovation: A Comparative Analysis of Economic Benefits Gained by Farmers under Climate Resilient and Conventional Agricultural Practices. *Land Use Policy* **2021**, *108*, 105581. [\[CrossRef\]](#)
53. Havardi-Burger, N.; Mempel, H.; Bitsch, V. Sustainability Challenges and Innovations in the Value Chain of Flowering Potted Plants for the German Market. *Sustainability* **2020**, *12*, 1905. [\[CrossRef\]](#)
54. Soviadan, M.K.; Kubik, Z.; Enete, A.A.; Okoye, C.U. Assessing the Adoption Rates of Improved Technology in Traditional Poultry Farming: Evidence from Rural Togo. *Afr. J. Agric. Resour. Econ.* **2022**, *17*, 206–223. [\[CrossRef\]](#)
55. Lutz, J.; Smetschka, B.; Grima, N. Farmer Cooperation as a Means for Creating Local Food Systems-Potentials and Challenges. *Sustainability* **2017**, *9*, 925. [\[CrossRef\]](#)
56. Alemu, S.; Kosmowski, F.; Stevenson, J.R.; Mallia, P.; Taye, L.; Macours, K. Studying Inclusive Innovation with the Right Data: An Empirical Illustration from Ethiopia. *Agric. Syst.* **2024**, *219*, 103988. [\[CrossRef\]](#)
57. Martens, K.; Rogga, S.; Hardner, U.; Piore, A. Examining Proximity Factors in Public-Private Collaboration Models for Sustainable Agri-Food System Transformation: A Comparative Study of Two Rural Communities. *Front. Sustain. Food Syst.* **2023**, *7*, 1248124. [\[CrossRef\]](#)
58. de Witt, M.; de Clercq, W.P.; Velazquez, F.J.B.; Altobelli, F.; Marta, A.D. An In-Depth Evaluation of Personal Barriers to Technology Adoption in Irrigated Agriculture in South Africa. *Outlook Agric.* **2021**, *50*, 259–268. [\[CrossRef\]](#)
59. Kong, R.; Castella, J.-C. Farmers' Resource Endowment and Risk Management Affect Agricultural Practices and Innovation Capacity in the Northwestern Uplands of Cambodia. *Agric. Syst.* **2021**, *190*, 103067. [\[CrossRef\]](#)
60. Crivits, M.; De Krom, M.P.M.M.; Dessein, J.; Block, T. Why Innovation Is Not Always Good: Innovation Discourses and Political Accountability. *Outlook Agric.* **2014**, *43*, 147–155. [\[CrossRef\]](#)
61. Kumar, A.; Takeshima, H.; Thapa, G.; Adhikari, N.; Saroj, S.; Karkee, M.; Joshi, P.K. Adoption and Diffusion of Improved Technologies and Production Practices in Agriculture: Insights from a Donor-Led Intervention in Nepal. *Land Use Policy* **2020**, *95*, 104621. [\[CrossRef\]](#)
62. Senyolo, M.P.; Long, T.B.; Blok, V.; Omta, O. How the Characteristics of Innovations Impact Their Adoption: An Exploration of Climate-Smart Agricultural Innovations in South Africa. *J. Clean. Prod.* **2018**, *172*, 3825–3840. [\[CrossRef\]](#)
63. Gwara, S.; Wale, E.; Lundhede, T.; Jourdain, D.; Odindo, A. Ex-Ante Demand Assessment and Willingness to Pay for Human Excreta Derived Co-Compost: Empirical Evidence from Rural South Africa. *J. Clean. Prod.* **2023**, *388*, 135570. [\[CrossRef\]](#)
64. Ayisi, D.N.; Kozári, J.; Krisztina, T. Do Smallholder Farmers Belong to the Same Adopter Category? An Assessment of Smallholder Farmers Innovation Adopter Categories in Ghana. *Heliyon* **2022**, *8*, e10421. [\[CrossRef\]](#)
65. Wang, X.; Cui, C.; Xu, M.; Cheng, B.; Zhuang, M. Key Technologies Improvements Promote the Economic-Environmental Sustainability in Wheat Production of China. *J. Clean. Prod.* **2024**, *443*, 141230. [\[CrossRef\]](#)
66. D'Alberto, R.; Targetti, S.; Schaller, L.; Bartolini, F.; Eichhorn, T.; Haltia, E.; Harmanny, K.; Le Gloux, F.; Nikolov, D.; Runge, T.; et al. A European Perspective on Acceptability of Innovative Agri-Environment-Climate Contract Solutions. *Land Use Policy* **2024**, *141*, 107120. [\[CrossRef\]](#)
67. Osewe, M.; Liu, A.; Njagi, T. Farmer-Led Irrigation and Its Impacts on Smallholder Farmers' Crop Income: Evidence from Southern Tanzania. *Int. J. Environ. Res. Public Health* **2020**, *17*, 1512. [\[CrossRef\]](#) [\[PubMed\]](#)

68. Gil, J.; Siebold, M.; Berger, T. Adoption and Development of Integrated Crop-Livestock-Forestry Systems in Mato Grosso, Brazil. *Agric. Ecosyst. Environ.* **2015**, *199*, 394–406. [\[CrossRef\]](#)
69. Arsil, P.; Tey, Y.S.; Brindal, M.; Ardiansyah; Sumarni, E.; Masrukhi. Perceived Attributes Driving the Adoption of System of Rice Intensification: The Indonesian Farmers' View. *Open Agric.* **2022**, *7*, 217–225. [\[CrossRef\]](#)
70. Adnan, N.; Nordin, S.M.; Rasli, A.M. A Possible Resolution of Malaysian Sunset Industry by Green Fertilizer Technology: Factors Affecting the Adoption among Paddy Farmers. *Environ. Sci. Pollut. Res.* **2019**, *26*, 27198–27224. [\[CrossRef\]](#)
71. Horn, E.K.; Joyce, A.; Chowdhury, R.B.; Caputo, S.; Jacobs, B.; Winkler, M.; Proksch, G. Translating Environmental Potential to Economic Reality: Assessment of Commercial Aquaponics through Sustainability Transitions Theory. *Circ. Econ. Sustain.* **2024**, *4*, 523–554. [\[CrossRef\]](#)
72. García-Granero, E.M.; Piedra-Muñoz, L.; Galdeano-Gómez, E. Measuring Eco-Innovation Dimensions: The Role of Environmental Corporate Culture and Commercial Orientation. *Res. Policy* **2020**, *49*, 104028. [\[CrossRef\]](#)
73. Ndah, H.T.; Schuler, J.; Nkwain, V.N.; Nzogela, B.; Mangesho, W.; Mollel, R.; Loina, R.; Zander, P.; Paul, B.K. Determinants for Smallholder Farmers' Adoption of Improved Forages in Dairy Production Systems: The Case of Tanga Region, Tanzania. *Agronomy* **2022**, *12*, 305. [\[CrossRef\]](#)
74. Lanker, M.; Bell, M.; Picasso, V.D. Farmer Perspectives and Experiences Introducing the Novel Perennial Grain Kernza Intermediate Wheatgrass in the US Midwest. *Renew. Agric. Food Syst.* **2020**, *35*, 653–662. [\[CrossRef\]](#)
75. Kafetzopoulos, D.; Vouzas, F.; Skalkos, D. Developing and Validating an Innovation Drivers' Measurement Instrument in the Agri-Food Sector. *Br. Food J.* **2020**, *122*, 1199–1214. [\[CrossRef\]](#)
76. Borges, J.A.R.; Oude Lansink, A.G.J.M. Identifying Psychological Factors That Determine Cattle Farmers' Intention to Use Improved Natural Grassland. *J. Environ. Psychol.* **2016**, *45*, 89–96. [\[CrossRef\]](#)
77. Brugere, C.; Padmakumar, K.P.; Leschen, W.; Tocher, D.R. What Influences the Intention to Adopt Aquaculture Innovations? Concepts and Empirical Assessment of Fish Farmers' Perceptions and Beliefs about Aquafeed Containing Non-Conventional Ingredients. *Aquac. Econ. Manag.* **2021**, *25*, 339–366. [\[CrossRef\]](#)
78. Fall, M.G.; Toure, K.; Diallo-Diagne, N.H.; Sall, M.; Diouf, L.; Ndiaye, S. Multi-Criteria Analysis of Adoption Paths for Fertiliser Resource Optimisation Technologies. *Int. J. Biol. Chem. Sci.* **2024**, *18*, 882–893. [\[CrossRef\]](#)
79. Zulfiqar, F.; Datta, A.; Tsusaka, T.W.; Yaseen, M. Micro-Level Quantification of Determinants of Eco-Innovation Adoption: An Assessment of Sustainable Practices for Cotton Production in Pakistan. *Sustain. Prod. Consum.* **2021**, *28*, 436–444. [\[CrossRef\]](#)
80. Yu, H.; Chen, Y.; Yang, Y.; Zhao, H.; Xie, Y.; Maria, U. Narrowing the Gaps between Perception and Adoption Behavior of Integrated Pest Management by Farmers: Incentive and Challenge. *J. Clean. Prod.* **2024**, *480*, 144117. [\[CrossRef\]](#)
81. Moglia, M.; Alexander, K.S.; Thephavanh, M.; Thamavong, P.; Sodahak, V.; Khounsy, B.; Vorlasan, S.; Larson, S.; Connell, J.; Case, P. A Bayesian Network Model to Explore Practice Change by Smallholder Rice Farmers in Lao PDR. *Agric. Syst.* **2018**, *164*, 84–94. [\[CrossRef\]](#)
82. Hyland, J.J.; Heanue, K.; McKillop, J.; Micha, E. Factors Underlying Farmers' Intentions to Adopt Best Practices: The Case of Paddock Based Grazing Systems. *Agric. Syst.* **2018**, *162*, 97–106. [\[CrossRef\]](#)
83. Zulfiqar, F.; Thapa, G.B. Determinants and Intensity of Adoption of "Better Cotton" as an Innovative Cleaner Production Alternative. *J. Clean. Prod.* **2018**, *172*, 3468–3478. [\[CrossRef\]](#)
84. Brooks, S.; Loevinsohn, M. Shaping Agricultural Innovation Systems Responsive to Food Insecurity and Climate Change. *Nat. Resour. Forum* **2011**, *35*, 185–200. [\[CrossRef\]](#)
85. Prasad, P.V.V.; Bhatnagar, N.; Bhandari, V.; Jacob, G.; Narayan, K.; Echeverría, R.; Beintema, N.; Farah Cox, P.; Compton, J. Patterns of Investment in Agricultural Research and Innovation for the Global South, with a Focus on Sustainable Agricultural Intensification. *Front. Sustain. Food Syst.* **2023**, *7*, 1108949. [\[CrossRef\]](#)
86. Aboagye-Darko, D.; Mkhize, P. Unearthing the Determinants of Digital Innovation Adoption in the Agricultural Sector: The Role of Food Security Awareness and Agricultural Experience. *Heliyon* **2025**, *11*, e41695. [\[CrossRef\]](#)
87. Finger, R. Digital Innovations for Sustainable and Resilient Agricultural Systems. *Eur. Rev. Agric. Econ.* **2023**, *50*, 1277–1309. [\[CrossRef\]](#)
88. Tunio, R.A.; Li, D.; Khan, N. Maximizing Farm Resilience: The Effect of Climate Smart Agricultural Adoption Practices on Food Performance amid Adverse Weather Events. *Front. Sustain. Food Syst.* **2024**, *8*, 1423702. [\[CrossRef\]](#)
89. Digitalisation—European Commission. Available online: [https://agriculture.ec.europa.eu/overview-vision-agriculture-food/digitalisation\\_en](https://agriculture.ec.europa.eu/overview-vision-agriculture-food/digitalisation_en) (accessed on 31 July 2025).
90. Colovic, A.; Caloffi, A.; Rossi, F.; Russo, M. Institutionalising the Digital Transition: The Role of Digital Innovation Intermediaries. *Res. Policy* **2025**, *54*, 105146. [\[CrossRef\]](#)
91. Fiore, M.; Frem, M.; Mongiello, M.; Bozzo, F.; Montemurro, C.; Tricarico, G.; Petrontino, A. Blockchain-Based Food Traceability in Apulian Marketplace: Improving Sustainable Agri-Food Consumers Perception and Trust. *Internet Technol. Lett.* **2024**, *7*, e503. [\[CrossRef\]](#)

92. Ellahi, R.M.; Wood, L.C.; Bekhit, A.E.-D.A. Blockchain-Driven Food Supply Chains: A Systematic Review for Unexplored Opportunities. *Appl. Sci.* **2024**, *14*, 8944. [\[CrossRef\]](#)
93. Morrison, R. Farmer Networks and the Adoption of Agricultural Innovations in East Africa. Ph.D. Thesis, The University of Edinburgh, Edinburgh, UK, 2023.
94. Belamkar, P.; Biswas, S.; Baidya, A.; Majumder, P.; Bera, U.K. Multi-Objective Optimization of Agro-Food Supply Chain Networking Problem Integrating Economic Viability and Environmental Sustainability through Type-2 Fuzzy-Based Decision Making. *J. Clean. Prod.* **2023**, *421*, 138294. [\[CrossRef\]](#)
95. Visser, J.; Wangu, J. Women's Dual Centrality in Food Security Solutions: The Need for a Stronger Gender Lens in Food Systems' Transformation. *Curr. Res. Environ. Sustain.* **2021**, *3*, 100094. [\[CrossRef\]](#)
96. de Boon, A.; Sandström, C.; Rose, D.C. Governing Agricultural Innovation: A Comprehensive Framework to Underpin Sustainable Transitions. *J. Rural. Stud.* **2022**, *89*, 407–422. [\[CrossRef\]](#)
97. Stroh, T.; Mention, A.-L.; Duff, C. How Do Psychological Factors Affect Innovation and Adoption Decisions? *Int. J. Innov. Mgt.* **2022**, *26*, 2240026. [\[CrossRef\]](#)
98. Ajzen, I. The Theory of Planned Behavior. *Organ. Behav. Hum. Decis. Process.* **1991**, *50*, 179–211. [\[CrossRef\]](#)
99. Stern, P.C. New Environmental Theories: Toward a Coherent Theory of Environmentally Significant Behavior. *J. Soc. Issues* **2000**, *56*, 407–424. [\[CrossRef\]](#)
100. Nakano, Y.; Tsusaka, T.W.; Aida, T.; Pedo, V.O. Is Farmer-to-Farmer Extension Effective? The Impact of Training on Technology Adoption and Rice Farming Productivity in Tanzania. *World Dev.* **2018**, *105*, 336–351. [\[CrossRef\]](#)
101. Pan, D.; Kong, F.; Zhang, N.; Ying, R. Knowledge Training and the Change of Fertilizer Use Intensity: Evidence from Wheat Farmers in China. *J. Environ. Manag.* **2017**, *197*, 130–139. [\[CrossRef\]](#)
102. Montes de Oca Munguia, O.; Pannell, D.J.; Llewellyn, R. Understanding the Adoption of Innovations in Agriculture: A Review of Selected Conceptual Models. *Agronomy* **2021**, *11*, 139. [\[CrossRef\]](#)
103. Klerkx, L.; Van Mierlo, B.; Leeuwis, C. Evolution of Systems Approaches to Agricultural Innovation: Concepts, Analysis and Interventions. In *Farming Systems Research into the 21st Century: The New Dynamic*; Darnhofer, I., Gibbon, D., Dedieu, B., Eds.; Springer: Dordrecht, The Netherlands, 2012; pp. 457–483, ISBN 978-94-007-4502-5.
104. Spielman, D.J.; Birner, R. *How Innovative Is Your Agriculture? Using Innovation Indicators and Benchmarks to Strengthen National Agricultural Innovation Systems*; World Bank: Washington, DC, USA, 2008.
105. Bozzo, F.; Frem, M.; Fucilli, V.; Cardone, G.; Garofoli, P.F.; Geronimo, S.; Petrontino, A. Landscape and Vegetation Patterns Zoning Is a Methodological Tool for Management Costs Implications Due to Xylella Fastidiosa Invasion. *Land* **2022**, *11*, 1105. [\[CrossRef\]](#)
106. Petrontino, A.; Frem, M.; Fucilli, V.; Tricarico, G.; Bozzo, F. Health-Nutrients and Origin Awareness: Implications for Regional Wine Market-Segmentation Strategies Using a Latent Analysis. *Nutrients* **2022**, *14*, 1385. [\[CrossRef\]](#)

**Disclaimer/Publisher's Note:** The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.

## **GENERAL CONCLUSION**

## **1. Recapitulation: Confronting the central challenge**

This doctoral thesis embarked on a comprehensive investigation to decode one of the most persistent challenges in the contemporary agri-food system: the innovation gap. As established at the Introduction section, the global mission to feed a growing population while protecting the environment is heavily reliant on innovation. Yet, as policies like the European Green Deal underscore, the pathway from a promising innovation to widespread impact is fraught with obstacles. This research was predicated on the core thesis that the sustainable transition is not merely a technological challenge but a profound socio-economic one, hinging on a critical alignment between the supply-side capacity to adopt innovations and the demand-side willingness to validate them in the marketplace.

The initial chapters laid bare the problem: innovations often stall due to a complex web of economic, institutional, and behavioural barriers on the producer side, while on the consumer side, a persistent "attitude-behaviour gap" means that professed values do not always translate into purchasing decisions. This disconnect represents a fundamental market failure, where sustainable producers are not adequately rewarded, and their investments in innovation are thereby de-risked. This doctoral research directly addressed this gap by constructing a holistic, dual-perspective framework, integrating a macro-level systematic review of global adoption factors with micro-level empirical studies quantifying Italian consumers' Willingness to Pay (WTP) for innovative credence attributes across three strategically selected sectors. The journey through the sea urchin, pasta, and ornamental plant markets, framed by a global analysis of producer behaviour, provides a robust, evidence-based narrative on how to bridge this chasm.

## **2. From empirical findings to overarching answers**

The value of this multi-method, multi-sector approach lies in the cohesive story that emerges when the findings are woven together. The research questions posed at the inception of this journey find their answers not in isolation, but in the interplay between the different studies.

### **2.1. The quantifiable demand for trust and transparency (addressing RQ1 & RQ2)**

The PhD thesis provides unequivocal, quantitative evidence that Italian consumers are not passive price-takers; they are active value-seekers. The economic valuations (WTP) uncovered are significant and context-dependent.

In the sea urchin market, a high-value heritage product, the premium for certification of origin (€26.27) dwarfs other attributes. This demonstrates that in contexts where identity and risk mitigation are paramount, consumers seek and are willing to pay a substantial premium for institutionalized trust. This is not just a purchase; it is an investment in cultural heritage and food safety.

For pasta, a mass-market staple, the value of blockchain-based traceability (up to €1.16 premium) lies in its ability to deliver radical transparency. Consumers are not paying for the blockchain technology per se, but for the unforgeable guarantee of food safety and sustainable production practices it enables. This finding demystifies digital innovation, anchoring its value in tangible consumer benefits.

In the ornamental plants sector, the WTP for plant health diagnostics (€1.10) and sustainable cultivation (€0.90) proves that the principles of sustainability and risk mitigation transcend the edible domain. In the shadow of a phytosanitary crisis like *Xylella fastidiosa*, consumers perceive value in

assurances of plant health and environmentally sound nursery management, extending the credence economy into the garden.

These findings collectively affirm that the "credence attribute" is a central unit of value in the modern agri-food system. The economic signal is clear: there is a viable market for certified, transparent, and sustainable products.

## **2.2. The centrality of heterogeneity and segmentation (addressing RQ3)**

A one-size-fits-all approach is a recipe for failure. The methodological rigor of this thesis, employing Latent Class Analysis and Structural Equation Modelling, moved beyond aggregate findings to uncover the rich tapestry of consumer motivations.

The sea urchin study likely revealed segments ranging from "Traditionalists", driven solely by origin, to "Quality Universalists", who value a combination of attributes.

The pasta study explicitly integrated psychographics, showing that an individual's "attention to credence attributes" and "beliefs in traceability" are latent variables that powerfully moderate their WTP. This explains why two consumers, demographically identical, may value blockchain entirely differently.

The ornamental plants study successfully identified a distinct segment of "Quality-Seeking Enthusiasts" (30% of the sample) who exhibited a markedly higher WTP for sustainable and diagnostic attributes.

This consistent finding of heterogeneity is not a complication but a clarion call for precision. It dictates that effective market strategies and policies must be segmented and tailored, speaking directly to the motivations of specific consumer groups rather than a mythical "average" consumer.

## **2.3. Reframing the innovation ecosystem: An integrated view (addressing RQ4 & RQ5)**

The most significant contribution of this PhD thesis is the explicit integration of the demand and supply perspectives, moving beyond a siloed understanding.

The systematic review (Chapter 4) provided the macro-context, crystallizing the adoption process as a complex interplay of: (i) Extrinsic factors: economic costs, policy frameworks, market access; (ii) Intrinsic factors: farmer knowledge, perceptions, and attitudes; and (iii) Intervening factors: access to training, extension services, and collaborative networks.

This PhD thesis demonstrates that consumer WTP, as quantified in Chapters 1-3, directly influences all three categories. It acts as a powerful *extrinsic* economic incentive by increasing the potential ROI of an innovation. It can reshape *intrinsic* attitudes by demonstrating market acceptance, thereby increasing the perceived usefulness, and reducing the perceived risk of adoption. Finally, it can strengthen *intervening* factors by creating a business case for cooperatives and service providers to offer the necessary training and support.

Furthermore, this doctoral research illuminates a critical, often overlooked dynamic: consumer demand can function as a de facto market-based institution. The high WTP for certified sea urchin, for instance, could incentivize the bottom-up development of a new certification body, driven by market forces rather than top-down policy. This complements the systematic review's finding that

"institutional purpose" is the least explored dimension of innovation, suggesting that future institutional analyses must account for the role of market signals in shaping governance structures.

The overarching implication is that policy and business strategies must be designed to foster this virtuous cycle. For practitioners, this means investing in the certifications and traceability systems that consumers value and communicating their benefits effectively. For policymakers, it means designing support mechanisms, such as grants for certification schemes, subsidies for traceability technology, and knowledge-transfer programs, that are informed by and aligned with demonstrated consumer demand, thereby ensuring public funds effectively leverage market pull.

### **3. Methodological and personal reflections on an interdisciplinary journey**

The pursuit of this doctoral research was itself an exercise in the kind of synthesis it advocates for. To truly grasp the innovation ecosystem, one cannot remain within the confines of a single discipline. This doctoral journey required the analytical precision of agricultural economics to model WTP, the behavioural insights of consumer psychology to understand latent motivations, the strategic lens of business management to interpret managerial decisions, and the technical awareness of plant science and food technology to contextualize the innovations themselves.

The 18-month stage with LEADER S.C.C. and the 6-month period in Tirana were not mere adjuncts to the research; they were integral to its formulation. The direct engagement with agri-food cooperatives provided a ground-level view of the real-world barriers and strategic calculus behind innovation adoption process, vividly bringing to life the factors identified in the systematic review. The international experience in Albania offered a comparative perspective, highlighting how contextual variables, cultural, economic, and institutional, profoundly shape the innovation landscape. This blend of quantitative rigor, qualitative insight, and practical immersion has instilled a deep conviction that robust, transdisciplinary evidence is the most powerful tool for building consensus and driving change among diverse stakeholders.

### **4. A roadmap for future inquiry**

By providing definitive answers, this PhD thesis also charts a course for future research, identifying several critical avenues for further exploration.

From stated to revealed preferences: A logical and crucial next step is to bridge the final mile of the "attitude-behaviour gap". Future research should combine the stated preference methods (DCEs) used here with revealed preference data from actual market sales, perhaps through controlled store experiments or scanner data analysis, to understand the conditions under which WTP translates into real purchases.

Cross-cultural and generational dynamics: How portable are these findings? Replicating this multi-sectoral study in other cultural contexts (e.g., Northern vs. Southern Europe) would be highly informative. Furthermore, a dedicated focus on Generations Z and Alpha, whose digital nativity and value systems may redefine market dynamics, is essential for future-proofing agri-food strategies.

The producer's balance sheet: While this thesis quantified the demand-side value, a complete picture requires detailed cost-benefit analyses from the producer perspective. Future work should rigorously calculate the costs of implementing certifications, blockchain systems, and diagnostic protocols for SMEs, enabling a direct comparison with the WTP findings to assess true economic viability.

Expanding the sectoral and technological scope: The integrated framework developed here is highly transferable. Applying it to other pressing sectors such as the wine industry (water-saving tech), dairy (animal welfare), or the nascent insect-protein market, could yield equally valuable insights. Similarly, exploring consumer and producer responses to the next wave of innovations, such as AI-driven precision agriculture or gene-edited crops, is a fertile ground for research.

The Co-evolution of markets and institutions: A deeper dive into the institutional dimension is warranted. How does demonstrated consumer demand, as quantified here, actually influence policy-making and standard-setting bodies? Research could track the evolution of market-driven standards and analyse the policy mechanisms that most effectively amplify consumer signals to producers.

## **5. Conclusive vision**

This research began with the identification of a broken cycle, where innovation was pushed without a clear understanding of market pull. It concludes by demonstrating that the circuit can be closed. The consistent narrative across diverse products, from the shores of Puglia to the pasta aisle and the local nursery, is that sustainability, trust, and transparency are not niche concerns but foundational elements of modern value creation.

The "credence economy" is not a future concept; it is a present-day reality, and this thesis has provided the tools to measure its currency. The journey of this PhD demonstrates that the agri-food system's sustainable transition will be built not by technological silver bullets, but by meticulously building bridges, bridges of data that connect consumer values to producer incentives, bridges of collaboration that unite stakeholders across the value chain, and bridges of trust that are certified, transparent, and ultimately, paid for. The result is a vision for a resilient agri-food system that is not only productive and sustainable but also profoundly connected, where every link in the chain, from the soil to the consumer, is reinforced by shared and demonstrable value.

**Annexe A – *Relazione Triennale***

# **UNIVERSITÀ DEGLI STUDI DI BARI ALDO MORO**

## **DIPARTIMENTO DI SCIENZE DEL SUOLO DELLA PIANTA E DEGLI ALIMENTI**

### **DOTTORATO DI RICERCA IN SCIENZE DEL SUOLO E DEGLI ALIMENTI**

#### **RELAZIONE TRIENNALE SULL'ATTIVITÀ SVOLTA**

Nell'ambito della borsa di dottorato a valere sul PNRR, Missione 4, componente 1 “Potenziamento dell’offerta dei servizi di istruzione: dagli asili nido all’Università” - Investimento 3.4 “Didattica e competenze universitarie avanzate” e Investimento 4.1 “Estensione del numero di dottorati di ricerca e dottorati innovativi per la pubblica amministrazione e il patrimonio culturale”, D.M. 351 del 09.04.2022 o sul PNRR, Missione 4, componente 2 “Dalla Ricerca all'Impresa” - Investimento 3.3 “Introduzione di dottorati innovativi che rispondono ai fabbisogni di innovazione delle imprese e promuovono l’assunzione dei ricercatori dalle imprese”, D.M. 352 del 09.04.2022

|                       |                                                                                                                                                      |
|-----------------------|------------------------------------------------------------------------------------------------------------------------------------------------------|
| Dottorando            | Adele Annarita Campobasso                                                                                                                            |
| Tutor                 | Prof. Francesco Bozzo / Dott. Alessandro Petrontino                                                                                                  |
| Coordinatore          | Chiar.ma Prof.ssa Erica Pontonio                                                                                                                     |
| Corso di Dottorato    | Scienze del Suolo e degli Alimenti                                                                                                                   |
| Ciclo                 | XXXVIII                                                                                                                                              |
| Annualità della borsa | II semestre III anno                                                                                                                                 |
| CUP                   | H91I22000480007                                                                                                                                      |
| Codice borsa          | 38-033-02-DOT1302942-2920                                                                                                                            |
| Area Tematica         |                                                                                                                                                      |
| Titolo Progetto       | Analisi dei risultati socioeconomici delle imprese in forma associativa e della loro propensione all’introduzione di innovazioni nell’agroalimentare |

\*

In piena coerenza con le attività previste dal progetto nell’ambito del quale è stata finanziata la borsa di dottorato, si presenta la relazione triennale dell’attività svolta.

**COORDINATORE: Chiar.ma Prof.ssa Erica Pontonio**

**TUTOR: Prof. Francesco Bozzo / Dott. Alessandro Petrontino**

**CO-TUTOR: Dott. Giovanni Tricarico / Prof. Fatmir Guri**

**Dottoranda: Adele Annarita Campobasso**



## 1 Introduzione

L'innovazione è un fattore imprescindibile del progresso economico che porta beneficio ai consumatori, alle imprese e all'economia nel suo insieme. Nell'attuale contesto economico e sociale, l'innovazione è uno dei principali driver di sviluppo territoriale, nonché un elemento determinante per la crescita di qualsiasi impresa.

Il processo di innovazione è un fenomeno sistemico e l'innovazione il risultato di una complessa rete di relazioni e flussi di conoscenza che hanno luogo sia all'interno del perimetro organizzativo dell'impresa, sia nel luogo figurato racchiuso tra l'impresa ed il contesto esterno ad essa. Nel corso degli ultimi anni, è stato ampiamente dimostrato, infatti, che i modelli di relazione tra pubbliche amministrazioni, imprese ed enti di ricerca, sono improntati sulle capacità di messa in rete tra innovatori, persone in grado di trasmettere valori, concezioni, tensione proattiva all'innovazione ad altri membri appartenenti alla rete comune o alle proprie organizzazioni. Pertanto, il grado di apertura delle imprese al contesto esterno e la propria capacità di relazionarsi e cooperare, sui temi della ricerca e dell'innovazione, sono riconosciuti da molto tempo come elementi di cruciale importanza, in grado di influire sul dinamismo tecnologico delle imprese e sulle loro prestazioni innovative e, più in generale, sulle prestazioni del sistema nazionale d'innovazione di cui sono parte integrante.

Attraverso l'innovazione le aziende hanno la possibilità di raggiungere un vantaggio competitivo all'interno del mercato in cui operano, oppure, se si trovano in una posizione di svantaggio, recuperare terreno dalla concorrenza. D'altra parte, il sistema della conoscenza ha bisogno di un continuo confronto con il mondo produttivo al fine di orientare al meglio gli ambiti della ricerca, calibrare le proprie indagini sulla base di feedback qualificati e sull'interscambio di dati empirici che possano dare validità e rilevanza ai risultati ottenuti in ambito sperimentale.

Nell'attuale contesto geopolitico, sociale, economico e climatico in continua trasformazione, la ricerca sui grandi temi è una delle chiavi fondamentali per costruire un'Europa e un'Italia che possano proporsi come società e comunità più inclusive, resilienti e sostenibili, offrendo alle imprese gli strumenti necessari a comprendere e affrontare le grandi sfide poste dalla globalizzazione.

Le strategie promosse negli ultimi anni (Europa 2020, Green Deal, Farm to Fork, SDGs, ecc.), nonché il programma di finanziamento per la ricerca e l'innovazione Horizon Europe (2021-2027), a favore della transizione verso sistemi alimentari ecologici, digitali e sostenibili, si inseriscono in questo contesto guardando ad un nuovo modello di crescita e di sviluppo economico (più intelligente, sostenibile ed inclusivo) e chiedendo che la ricerca e l'innovazione operino in stretta connessione con le esigenze di cittadini e imprese [1].

In linea con questo approccio, la nuova programmazione 2023-2027 della strategia nazionale approvata con la decisione comunitaria sul Piano Strategico della PAC (PSP) ha previsto, tra i suoi obiettivi tematici, l'obiettivo trasversale di "modernizzare l'agricoltura e le aree rurali promuovendo e condividendo conoscenza, innovazione e digitalizzazione nell'agricoltura" [2]. Pertanto, il rafforzamento della ricerca, dello sviluppo tecnologico e dell'innovazione mira a guidare il settore agroalimentare nella transizione ecologica volta a promuovere e sostenere la competitività delle piccole e medie imprese (PMI) in una logica di crescita sostenibile, attraverso la creazione di azioni virtuose di collaborazione, l'adozione di innovazione e di strumenti che favoriscano la digitalizzazione di strutture e di processi produttivi.

La trasformazione digitale, assieme alle altre iniziative promosse per contrastare le Grand Challenges poste dalla globalizzazione, può rappresentare una grande opportunità per l'intera economia, fortemente supportata dalla visione generale alla base delle politiche e dei relativi investimenti a pioggia che l'Europa sta destinando a favore del nostro Paese.



Secondo l'Agenda 2030 dell'ONU [3], la trasformazione digitale rappresenta l'elemento cruciale per generare processi di sviluppo stabili, duraturi ed efficaci, rendendo possibile la costruzione di un ambiente favorevole allo sviluppo sostenibile. Infatti, sia il digitale che l'innovazione, nelle loro accezioni generali, sono considerati dalla stessa Agenda, fattori abilitanti per il raggiungimento di tutti i 17 Sustainable Development Goals (SDGs).

Nonostante l'importanza riconosciuta a livello globale dell'adozione dell'innovazione per raggiungere gli obiettivi di sviluppo sostenibile e migliorare la resilienza del sistema agroalimentare, persistono sfide significative per comprendere e facilitarne l'adozione nei vari contesti. I tassi di adozione rimangono al di sotto delle aspettative in molti Paesi, con una notevole eterogeneità nei modelli di adozione dell'innovazione tra diversi tipi di filiere, innovazioni e contesti geografici. A questa varietà di modelli si aggiunge la complessità delle catene di approvvigionamento, dove le decisioni di adozione sono influenzate non solo dalle caratteristiche individuali di ciascun attore, ma anche dalle dinamiche di filiera e dalle relazioni collaborative che intervengono sia tra individui che tra gruppi di persone con caratteristiche e bisogni di innovazione differenti, calati ciascuno in contesti caratterizzati da variabili istituzionali e governative peculiari.

In conclusione, l'introduzione di innovazione nel settore agroalimentare si può ricondurre ad un processo complesso attraverso il quale gli attori della filiera integrano nuove tecnologie, pratiche o metodi organizzativi nelle loro operazioni per migliorare l'efficienza, la sostenibilità e la competitività della propria impresa. All'interno di questa definizione ricade una vasta gamma di tipologie di innovazioni che vanno dai progressi tecnologici, come l'agricoltura di precisione e gli strumenti digitali applicati ai diversi processi, a nuove pratiche, come l'agricoltura conservativa o il recupero di antiche varietà, fino a nuove forme di modelli di business collaborativi, allineandosi con la oramai conclamata natura multidimensionale dell'innovazione nei diversi sistemi agricoli [4, 5].

## 2 Obiettivo

Nel corso del triennio sono stati perseguiti diversi obiettivi specifici volti a contribuire operativamente all'obiettivo generale del progetto di ricerca, ovvero contribuire alla disamina dei processi di innovazione nel settore agroalimentare, con un approfondimento sulla propensione ad introdurre innovazione, attraverso la sinergia tra il sistema della ricerca ed il sistema di rappresentanza delle imprese. Nello specifico il progetto mira ad ampliare le conoscenze in merito ai fattori che favoriscono l'implementazione di innovazione da parte delle imprese agroalimentari associate, attraverso specifici modelli di analisi che valuteranno la sostenibilità economica, sociale ed ambientale, verificando l'efficacia della metodologia applicata ed il raggiungimento degli obiettivi di intervento ed i fattori di successo per proporre eventuali azioni correttive e/o migliorative. Nello specifico un primo obiettivo ha riguardato la classificazione dei principali approcci e strumenti innovativi, valutati in maniera critica assieme ai fattori riconosciuti dalla comunità scientifica mondiale sul tema dell'adozione di innovazione nel settore agroalimentare. Un secondo obiettivo ha riguardato l'approfondimento delle implicazioni legate all'adozione di tecnologie digitali e pratiche innovative e l'accettazione da parte del consumatore. Infine, un terzo obiettivo ha riguardato il coinvolgimento e l'analisi diretta delle modalità con cui le imprese agroalimentari associate sotto il profilo economico, sociale e ambientale partecipano ai processi tesi ad introdurre innovazioni, attraverso l'esperienza di stage presso l'azienda Leader Società Cooperativa Consortile.

## 3 Materiali e metodi e piano sperimentale

La ricerca, l'innovazione e la formazione sono le chiavi per rispondere in maniera concreta



alle sfide del settore agricolo, forestale e della pesca, nonché alla diffusa esigenza di sostenibilità. In questo contesto si inseriscono le diverse attività svolte nel corso dei tre anni di ricerca e formazione condotte durante il percorso dottorale, che ha visto avvicinarsi 12 mesi trascorsi presso l'Ente di Ricerca in Italia (Università degli Studi di Bari - Dipartimento di Scienze del Suolo, della Pianta e degli Alimenti), 6 presso quello estero (Agricultural University of Tirana - Department of Economy and Rural Development Policy) e 18 mesi di stage presso l'impresa co-finanziatrice del presente dottorato innovativo (Leader - Società Cooperativa Consortile).

Le diverse attività in cui si è articolato il presente progetto negli ultimi 3 anni, hanno contribuito sia allo stato della pratica che allo stato della teoria e possono essere ricondotte alle diverse sfere di azione dell'innovazione, che ricopre per sua natura un ruolo multidisciplinare, e che per questo necessita di una visione olistica dei temi.

Nell'ultimo decennio l'attenzione da parte del mondo accademico e di quello aziendale nei confronti dei fattori che possono guidare l'accettazione delle innovazioni da parte dei consumatori è aumentata. Infatti, affinché le aziende abbiano successo all'interno del mercato alimentare, la percezione delle innovazioni da parte dei consumatori e la loro volontà di adottarle sono cruciali [6].

Pertanto, in accordo con quanto inizialmente previsto dal progetto di ricerca presentato, il primo periodo di ricerca è stato speso nell'approfondimento del modello econometrico della choice experiment (DCE), per calcolare la disponibilità a pagare dei consumatori in tre distinti lavori.

I primi due studi, utilizzando un approccio DCE, perseguivano lo scopo di indagare le percezioni e la disponibilità a pagare dei consumatori italiani attraverso due indagini distinte. La prima approfondiva le preferenze dei consumatori pugliesi su piatti italiani a base di ricci di mare (una specie ittica edibile che ricopre un ruolo ecologico molto importante), mentre la seconda indagine riguardava l'innovazione nelle tecnologie sulla diagnostica delle piante e sugli attributi di coltivazione sostenibile nelle piante ornamentali da esterno.

In linea con questo approccio, è stato condotto un terzo studio che ha combinato questo modello econometrico (DCE) con il modello a variabile latente (SEM), allo scopo di testare le relazioni tra la "sensibilità alla tecnologia blockchain" e le variabili psicografiche dei consumatori, ovvero l' "attenzione nei confronti dei credence attributes" e le "credenze sulla tracciabilità" [7]. Lo studio in questione aveva l'obiettivo di esaminare la disponibilità a pagare (WTP) dei consumatori italiani per la pasta secca tracciata mediante l'utilizzo della tecnologia blockchain nei mercati locali, analizzando i loro comportamenti, decisioni di acquisto e preferenze in merito a questioni sociali, ambientali, legate alla qualità e alla sicurezza alimentare.

Affinché l'adozione di nuove pratiche e tecnologie possano produrre benefici economici per le imprese, è fondamentale informare adeguatamente i consumatori sul loro funzionamento, per conquistare la loro fiducia nella sicurezza e trasparenza lungo tutta la filiera, nonché per costruire la loro fiducia in essa stessa [8].

Sempre nell'ambito della tecnologia blockchain, la dottoranda ha intrapreso un'indagine coordinata dal gruppo di ricerca dell'Università degli Studi di Bari con cui collabora, uno studio che mira ad approfondire gli aspetti manageriali connessi all'adozione di questa innovazione, su un campione di micro e piccole imprese italiane del *food processing*, ovvero pasta, olio, formaggi e vino, prodotti agroalimentari di spicco nel panorama enogastronomico delle eccellenze italiane, riconosciute a livello internazionale.

Nel presente lavoro la dottoranda è stata coinvolta sin dai suoi esordi e, grazie a questo, ha potuto seguire la sua evoluzione e partecipare attivamente ai diversi step in cui il lavoro si è articolato. Il primo ha riguardato l'analisi della bibliografia di riferimento che ha permesso di delineare lo stato dell'arte delle conoscenze relative alle tematiche, di definire il quesito



di ricerca e di identificare le aziende agroalimentari che rispondessero alle caratteristiche identificate. Successivamente sono stati definiti i criteri di campionamento, volti a garantire solidità allo studio, e sono stati progettati il consenso informato da somministrare prima di sottoporre i manager ad intervista, ed il protocollo delle domande costruite espressamente per esplorare le motivazioni, i processi e gli impatti sull'organizzazione interna, in seguito all'adozione di questa innovazione.

La partecipazione a questo progetto di ricerca ha consentito alla dottoranda di approfondire la metodologia del *Multiple Case Study*, un approccio metodologico qualitativo che consente di analizzare in profondità un fenomeno attraverso il confronto tra più casi studio. Questa metodologia è particolarmente utile nelle ricerche che mirano ad esplorare dinamiche complesse [9], come l'adozione di innovazioni nel settore agroalimentare, permettendo di individuare somiglianze, differenze e fattori chiave che influenzano le decisioni degli attori coinvolti.

Parallelamente, nell'ambito di un'analisi del contesto teorico, sono stati individuati numerosi e diversificati studi presenti in letteratura aventi come obiettivo quello di indagare diversi aspetti legati all'innovazione in ambito agroalimentare. Questa analisi preliminare ha permesso di individuare alcuni gap messi in evidenza dalla comunità scientifica sul tema. Pertanto, allo scopo di esaminare il comportamento degli agricoltori e la loro disponibilità a adottare innovazioni, è stata intrapresa una revisione sistematica della letteratura, condotta secondo criteri rigorosi e supportata da framework metodologici strutturati.

Tale studio, attraverso un approccio integrativo e multidisciplinare per un'analisi più completa, mira ad ampliare gli strumenti di comprensione dei determinanti socio-economici, ambientali e istituzionali che influenzano il processo di adozione, nel generare effetti sulla propensione e sul grado di adesione delle imprese agroalimentari ai processi di innovazione. Infatti, la propensione ad introdurre innovazioni nel settore agroalimentare rappresenta un ambito di indagine estremamente promettente soprattutto in funzione della progettazione delle politiche pubbliche destinate a sostenere e potenziare la domanda stessa.

Il lavoro si è proposto di raggiungere diversi obiettivi strategici: in primo luogo, identificare le principali tipologie di innovazioni esplorate finora dalla comunità scientifica nella ricerca sull'introduzione di innovazione nelle imprese agroalimentari di tutto il mondo. Queste innovazioni sono state valutate in base alle finalità perseguite da ciascuna tipologia di innovazione all'interno di quadri di sostenibilità agricola, basandosi in particolar modo sul lavoro di Pretty [10], enfatizzando l'integrazione di processi biologici, la minimizzazione degli input dannosi e l'uso produttivo delle conoscenze e delle capacità collettive degli agricoltori. Le innovazioni sono state classificate in base a quattro dimensioni chiave: finalità ecologiche, economiche, sociali e istituzionali, seguendo l'approccio multifunzionale per cui i sistemi agricoli producono cibo e congiuntamente contribuiscono a beni pubblici di valore.

Un altro obiettivo di questo lavoro è stato quello di esaminare i fattori che influenzano la propensione ad introdurre innovazioni nel settore agroalimentare, utilizzando il quadro analitico proposto da Meijer et al. [5] che riconosce la complessa interazione tra variabili estrinseche (caratteristiche della tecnologia e attributi dell'ambiente esterno), intrinseche (conoscenze, percezioni e atteggiamenti dei potenziali utilizzatori) e “intervening” (meccanismi di diffusione, formazione e comunicazione, variabili cruciali per lo sviluppo di quelle intrinseche), che influenzano la propensione degli stakeholder a adottare innovazioni (Figural).

Infine, particolare attenzione è stata rivolta alla comprensione dei contesti in cui operano i potenziali adottanti, quelli geografici di appartenenza del campione e le filiere in cui si inseriscono, riconoscendone la capacità di integrarsi attraverso i processi di trasferimento tecnologico e cambiamento strutturale dei sistemi agroalimentari [11].

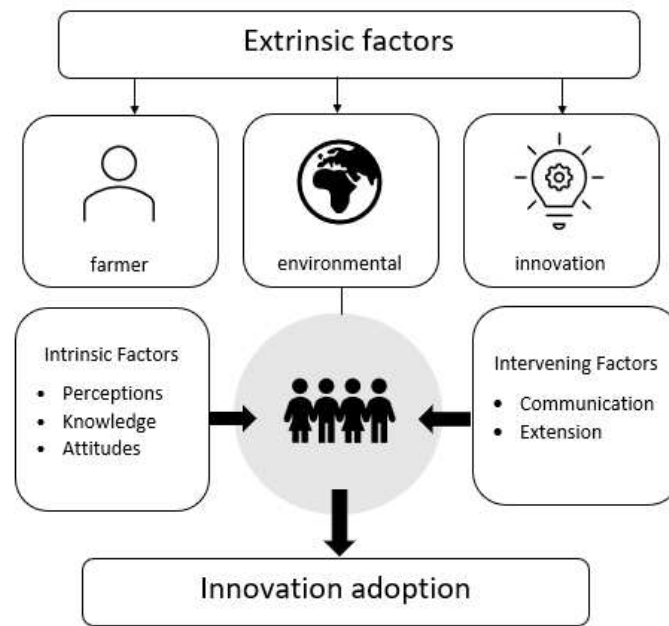


Figura 1. Quadro concettuale per la valutazione delle tre tipologie di variabili considerate nello studio. Il modello mostra l'interazione tra variabili estrinseche, intrinseche e “intervening” che influenzano le decisioni di adozione. Fonte: elaborazione propria.

Per raggiungere questi obiettivi e fornire nuove intuizioni scientifiche sugli approcci di ricerca multidisciplinari affrontati dalla comunità scientifica, è stato selezionato il metodo *PRISMA* di Page et al. [12] per garantire un approccio trasparente e rigoroso. Pertanto, i primi mesi del terzo anno sono stati dedicati all'approfondimento del *PRISMA 2020 Statement* che aggiorna le linee guida del 2009 per incorporare i progressi nella metodologia e nella terminologia delle revisioni sistematiche. Questo aggiornamento migliora la trasparenza nella reportistica, fornendo nuove raccomandazioni su come identificare, selezionare, valutare e sintetizzare gli studi. In particolare, il nuovo documento introduce una checklist di 27 elementi, una versione ampliata con linee guida dettagliate, una checklist per gli abstract e diagrammi di flusso rivisti per revisioni originali e aggiornate.

Contestualmente all’elaborazione di questi differenti lavori, è stata condotta l’attività di ricerca presso l’Azienda Leader – Società Cooperativa Consortile, che co-finanzia il presente dottorato innovativo e vede nella figura del Direttore generale, Dott. Giovanni Tricarico, il tutor aziendale.

Durante i 18 mesi di stage trascorsi in azienda è stata intrapresa inizialmente un'analisi del materiale documentale fornito dall'impresa che ha permesso di approfondire non solo la natura, la mission ed il bacino di fruitori dei servizi offerti, ma anche di analizzare le attività ed i servizi volti a promuovere l'innovazione nel comparto agroalimentare in cui l'impresa è coinvolta.

Successivamente, è stata avviata un'intensa attività di accompagnamento di imprese agroalimentari cooperative nella progettazione ed erogazione di servizi di consulenza nel campo della ricerca e sviluppo finalizzata ad implementare innovazioni di processo, prodotto, organizzative e di mercato, nel tessuto imprenditoriale pugliese e non solo. Leader, infatti, è società di servizi promossa da Confcooperative Puglia, Associazione di rappresentanza, assistenza e tutela del movimento cooperativo, e PMI Innovativa, iscritta nell'Albo dei Manager dell'Innovazione, in possesso di certificazione di Qualità ISO9001 e di Certificazione di Genere UNI PdR 125:2022.



Le attività hanno riguardato l'accompagnamento ed il coinvolgimento delle imprese agroalimentari associate sotto il profilo economico, sociale e ambientale, fortemente interessate ad introdurre innovazioni significative nella propria attività, attraverso strumenti finalizzati a potenziare e sostenere programmi di ricerca e di trasferimento tecnologico che vedono coinvolte le cooperative.

Tra le altre attività, la dottoranda ha affiancato il gruppo di ricercatori afferenti all'impresa nel coordinamento, sviluppo e attuazione delle diverse attività in cui si sono articolati due progetti di ambito agroalimentare, in cui Leader è partner, risultati vincitori tra quelli presentati durante lo scorso anno, e che vede in qualità di capofila il Politecnico di Bari - Dipartimento di ingegneria Elettrica e dell'Informazione.

I progetti rappresentano uno strumento di governance ampiamente utilizzato per raggiungere obiettivi relativi all'innovazione in ambito agricolo ed agroalimentare. Attori come la Commissione Europea, l'Organizzazione delle Nazioni Unite per l'Alimentazione e l'Agricoltura (FAO), così come i governi nazionali, hanno stanziato fondi per finanziare o sostenere in altro modo i progetti riconducibili all'innovazione agricola. Ad esempio, sul piano nazionale, il Piano Nazionale di Ripresa e Resilienza (PNRR) [13] prevede, attraverso gli strumenti finanziari e non, di cui si serve, di avvicinare le opportunità a sostegno della ricerca e sviluppo il più possibile anche alle piccole e medie imprese beneficiarie del Mezzogiorno, in una logica di prossimità, creando un effettivo coinvolgimento dei privati e favorendone la creazione di partnership virtuose, incoraggiando la nascita di reti di cooperazione che sostengono lo sviluppo di entrambe le parti.

È ormai consolidata da parte dei soggetti finanziatori la richiesta che i progetti vincitori documentino la loro efficacia nel produrre determinati effetti desiderati a breve e lungo termine. Pertanto, i risultati devono essere misurabili, ovvero le valutazioni d'impatto e di progetto riconducibili ad obiettivi di tipo economico e sociale, come ad esempio l'aumento della produttività o dell'occupazione, e, più recentemente, anche di tipo ambientale, come per esempio ciò che riguarda il recupero e la valorizzazione della biodiversità.

Un altro aspetto, riconducibile alle collaborazioni e consulenze necessarie alla multidisciplinarietà e all'implementazione finale delle innovazioni sottese ai progetti approvati, è l'approccio dell'"Open Innovation" che la dottoranda ha avuto modo di approfondire, attraverso l'attiva partecipazione ai due progetti, finanziati nell'ambito dei bandi a cascata. Infatti, essi prevedono la compartecipazione di esperti in possesso di competenze molto diverse tra loro ma strettamente legate dall'obiettivo comune di contestualizzare le innovazioni proposte, che, per loro natura, coinvolgono diversi ambiti della ricerca scientifica e tecnologica, all'interno delle specifiche realtà aziendali coinvolte. In generale l'"Open Innovation" rappresenta un modello di innovazione aziendale basato sulla gestione dei flussi di conoscenza in entrata o in uscita dall'impresa. Questo approccio strategico e culturale consente alle imprese di creare maggior valore ricorrendo non soltanto a idee e risorse interne ma anche a soluzioni che arrivano dall'esterno attraverso la collaborazione con università, spin-off, startup, istituti di ricerca, e così via, di cui i progetti di ricerca e sviluppo sono esempi virtuosi.

Il primo progetto finanziato persegue l'obiettivo di promuovere la sostenibilità delle filiere agroalimentari, nelle sue tre diverse accezioni, introducendo diversi tipi di innovazioni digitali ed organizzative testate su due cooperative del Mezzogiorno, che rappresentano i due casi studio. Attraverso un approccio integrato multidisciplinare, il progetto mira a definire dei modelli di contabilizzazione della sostenibilità delle produzioni ortofrutticole, a rendere più efficienti i processi produttivi ed a valorizzare le produzioni attraverso l'implementazione di diverse innovazioni.

Invece, il secondo progetto di ricerca, mira alla valorizzazione dei prodotti locali attraverso un percorso di sperimentazione di soluzioni tecnologiche, in grado di migliorare l'efficienza e l'efficacia dei processi produttivi delle filiere ortofrutticola ed olivicola-olearia.

## 4 Risultati

Per quanto concerne il modello econometrico della choice experiment, ha permesso di calcolare la disponibilità a pagare dei consumatori per piatti a base di ricci di mare concretizzandosi in una pubblicazione sulla rivista *foods*, il 16 gennaio 2023. Dai risultati ottenuti in questo lavoro si evince, a comprova dell'importanza del tema dell'innovazione in ambito agroalimentare, la necessità di anticipare e impostare strategie di mercato e di innovazione da parte degli attori economici coinvolti, che soddisfino le aspettative dei consumatori e migliorino le prestazioni economiche senza aumentare la pressione sulle risorse, in accordo con quanto promosso dall'impegno politico e sociale a tutti i livelli. Coerentemente, nel lavoro pubblicato su *Horticulturae* il 13 maggio 2024 lo stesso modello ha stimato che gli intervistati erano disposti a pagare un sovrapprezzo per una diagnosi innovativa delle piante e per pratiche di coltivazione sostenibile nella produzione di piante ornamentali da esterno. Questo studio fornisce preziose informazioni per il settore vivaistico, promuovendo per i gestori dei vivai strategie di marketing efficaci, che diano priorità alle certificazioni e all'etichettatura per l'assenza di malattie e incentivino la sostenibilità delle piante.

Lo studio condotto sulle preferenze di acquisto dei consumatori italiani per la pasta tracciata mediante tecnologia blockchain, è stato pubblicato il 14 marzo 2024 sulla rivista *Frontiers in Sustainable Food Systems*. L'indagine ha permesso di ottenere una base di dati utile ad orientare le aziende locali ad impostare strategie di mercato e di innovazione che sensibilizzino tutti gli stakeholders coinvolti lungo la filiera a soddisfare le aspettative dei consumatori e che, di conseguenza, migliorino le prestazioni finanziarie delle imprese. In particolare, i risultati ottenuti dallo studio condotto confermano la necessità di trasferire alle aziende agroalimentari locali potenzialità ed elementi di adeguamento finalizzati al loro successo e al loro posizionamento competitivo sul mercato, nonché la necessità di definire nuovi modelli di business riconducibili al tipo di filiera presa in esame.

Infine, l'approfondimento sul *Multiple Case Study* ha reso possibile un'analisi comparativa tra diverse imprese di *food processing* rispondenti ad una stringente strategia di campionamento, esaminando variabili come il contesto territoriale, le strategie aziendali e le motivazioni che promuovono l'adozione della tecnologia blockchain.

Dal punto di vista operativo, la metodologia applicata ha previsto una raccolta dati articolata, che ha riguardato sia la collezione di interviste, che quella di documentazione aziendale, dati secondari e altre fonti di informazione, che hanno ampliato il dataset arricchendolo di informazioni indispensabili per gli step successivi.

La dottoranda ha condotto e registrato le interviste con i referenti aziendali delle imprese che hanno deciso di aderire all'indagine, previa restituzione del consenso informato. Le trascrizioni ottenute costituiscono la base dati per l'analisi attualmente in corso, che prevede l'interpretazione dei risultati attraverso tecniche di estrazione delle informazioni testuali (*content analysis* con *qualitative research*).

La base dati attualmente è composta da quindici interviste della durata variabile da un minimo di 60 ad un massimo di 90 minuti, condotte con referenti aziendali, di altrettante aziende agroalimentari, che hanno introdotto la tecnologia blockchain per promuovere le caratteristiche peculiari e l'unicità dei propri prodotti sui mercati globali attraverso l'utilizzo di una tecnologia sicura e affidabile.

Il numero di imprese che attualmente costituiscono il campione non consente ancora una generalizzazione dei risultati del processo di codifica qualitativa. Tuttavia, al raggiungimento del numero di aziende soddisfacente, si identificheranno schemi ricorrenti e relazioni significative tra le variabili indagate, grazie anche alla triangolazione delle



informazioni contenute nel dataset.

L'applicazione di questo approccio nel contesto agroalimentare consentirà di ottenere una comprensione approfondita delle dinamiche decisionali alla base dell'adozione della tecnologia blockchain, e fornirà spunti utili sia per la ricerca scientifica che per le politiche di supporto al settore.

Per quanto riguarda la revisione sistematica della letteratura, la metodologia *PRISMA 2020* e i rigorosi criteri adottati hanno permesso di soddisfare tutte le domande di ricerca dello studio, concretizzandosi nel lavoro pubblicato sulla rivista *Agriculture* il 29 agosto 2025.

Tra i risultati principali vi sono le evidenze di una distribuzione tematica complessa in cui le innovazioni caratterizzate da fini ecologici dominano la ricerca, dimostrando sensibilità nei confronti della sostenibilità ambientale. Tuttavia, l'attenzione limitata alla conservazione della biodiversità suggerisce priorità ambientali "selettive".

L'analisi pluridimensionale delle innovazioni conferma l'approccio teorico di Cooper [4] riguardo alla natura multidimensionale dell'adozione dell'innovazione.

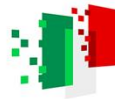
La collaborazione è emersa come elemento chiave trasversale: strumento di innovazione (ad esempio, le soluzioni contrattuali innovative, le reti di innovazione e i sistemi cooperativi), ma anche facilitatore per implementare strumenti e pratiche innovative. Inoltre, l'appartenenza ad una cooperativa è emersa sia come catalizzatore informativo che come meccanismo che facilita l'accesso alle tecnologie chiave, come sostenuto da Nakano et al. [14]. Ciò mette in discussione gli approcci individualistici all'adozione, sostenendo al contempo gli approcci di azione collettiva, facilitando lo scambio di informazioni tra i membri, promuovendo l'apprendimento reciproco e la condivisione di esperienze [15].

L'attività di stage svolta presso l'azienda Leader ha permesso l'arricchimento delle conoscenze personali e professionali della dottoranda e l'acquisizione di competenze, sia tecniche che trasversali, attraverso il coinvolgimento in progetti di ricerca e sviluppo di cui l'azienda è partner ufficiale.

Per quanto riguarda il primo progetto, la dottoranda ha preso parte alle riunioni di coordinamento con il personale interno all'impresa e a quelle previste con i partner. Inoltre, ha seguito le attività di progetto affiancando i ricercatori coinvolti nella definizione dello stato dell'arte e nella raccolta di materiale documentale relativo a sistemi di rendicontazione della sostenibilità in generale, e alle due cooperative coinvolte in particolare.

Diverse sono le innovazioni digitali introdotte nell'ambito di questo progetto, all'interno delle due cooperative, attualmente in fase di test. Sono state integrate varie innovazioni quali: la tecnologia blockchain, un canale di comunicazione con i clienti attraverso la realtà aumentata, la tecnologia digital twin e l'applicazione di modelli di intelligenza artificiale generativa. Inoltre, sono in fase di sperimentazione dei modelli di economia circolare che favoriscono il corretto approvvigionamento dei prodotti, per la promozione di una gestione degli scarti e dei sottoprodotti più oculata e per la destinazione dell'invenduto su canali solidali.

Per quanto concerne il secondo progetto di ricerca, la dottoranda ha preso parte alle attività di analisi delle due filiere individuate con lo Spoke e alla selezione dei cantieri sperimentali, collaborando alla stesura, relativamente alle suddette attività, della relazione tecnico-scientifica redatta dal gruppo di ricerca di Leader e dal personale coinvolto del Politecnico. In generale, la dottoranda ha maturato esperienza nella collaborazione all'interno di gruppi di lavoro multidisciplinari e nell'interazione con partner provenienti da settori diversi, contribuendo all'integrazione di prospettive eterogenee per affrontare le sfide poste dall'attuale esigenza di sostenibilità. L'attività svolta ha favorito lo sviluppo di capacità di analisi critica e problem solving in strategie operative concrete, grazie al confronto continuo e collaborativo con il gruppo di ricerca aziendale. Infine, la partecipazione a riunioni interne, così come le interazioni con i partner di progetto e con lo Spoke, hanno permesso di acquisire



esperienze inerenti alle collaborazioni interistituzionali ed alla gestione di attività progettuali complesse.

Questo percorso ha consentito di approfondire le dinamiche di trasferimento tecnologico e le strategie di valorizzazione dell'innovazione nel settore agroalimentare, rafforzando al contempo la capacità di adattamento a contesti lavorativi interdisciplinari caratterizzati da elevata complessità. Infatti, l'integrazione di conoscenze provenienti da ambiti differenti ha favorito un trasferimento tecnologico efficace e la co-creazione di soluzioni innovative.

Nel complesso, il coinvolgimento della dottoranda in questo contesto ha permesso di comprendere, attraverso l'esperienza sul campo, le dinamiche collaborative tipiche dell'Open Innovation, sviluppando competenze nella gestione di reti di conoscenza, nel coordinamento tra attori con background eterogenei e nell'identificazione di strategie per favorire l'adozione delle innovazioni nei processi produttivi agroalimentari.

Sarebbe interessante analizzare nell'attività di ricerca futura, gli effetti di ricaduta dei progetti di innovazione agricola in questione, sui sistemi di innovazione agricola (AIS) in cui operano le imprese beneficiarie dei finanziamenti.

L'innovazione agroalimentare non si limita all'adozione di nuove tecnologie, ma implica anche un equilibrio tra pratiche emergenti e modelli organizzativi alternativi. In questo processo, la collaborazione tra attori con competenze e prospettive differenti si rivela un elemento cruciale per sviluppare soluzioni efficaci e sostenibili. L'innovazione è un fenomeno complesso che coinvolge dimensioni sociali, economiche e istituzionali, e richiede un approccio integrato e multidisciplinare per affrontare le sfide attuali e future.

## 5 Bibliografia

1. Piano Strategico per l'innovazione e la ricerca nel settore agricolo alimentare e forestale (PSIR) 2014-2020.
2. Commissione Europea. La nuova Politica Agricola Comune: 2023-2027. 2023. <https://ec.europa.eu>.
3. Transforming our world: the 2030 Agenda for Sustainable Development. United Nations Member States. 2015. <https://sdgs.un.org/>.
4. Cooper, J.R. A Multidimensional Approach to the Adoption of Innovation. *Manag. Decis.* 1998, 36, 493–502.
5. Meijer, S.S.; Catacutan, D.; Ajayi, O.C.; Sileshi, G.W.; Nieuwenhuis, M. The Role of Knowledge, Attitudes and Perceptions in the Uptake of Agricultural and Agroforestry Innovations among Smallholder Farmers in Sub-Saharan Africa. *Int. J. Agric. Sustain.* 2015, 13, 40–54.
6. Siegrist, M. Factors influencing public acceptance of innovative food technologies and products. *Trends in Food Science & Technology.* 2008, 19, 11, 603-608.
7. Rungie, C. M.; Coote, L. V.; Louviere, J. J. Latent variables in discrete choice experiments. *J. Choice Model.* 2012, 5, 145–156. doi: 10.1016/j.jocm.2013.03.002.
8. Bandinelli, R.; Scozzafava, G.; Bindi, B.; Fani, V. Blockchain and consumer behaviour: Results of a technology acceptance model in the ancient wheat sector. *Cleaner Logistics and Supply Chain*, 2023, 8, 100117.
9. Kammerlander, N., Dessì, C., Bird, M., Floris, M., & Murru, A. The Impact of Shared Stories on Family Firm Innovation: A Multicase Study. *Family Business Review.* 2015, 28(4), 332-354.
10. Pretty, J. Agroecological Approaches to Agricultural Development; World Bank: Washington, DC, USA, 2006.



11. Barrett, C.B.; Reardon, T.; Swinnen, J.; Zilberman, D. Agri-Food Value Chain Revolutions in Low- and Middle-Income Countries. *J. Econ. Lit.* 2022, *60*, 1316–1377.
12. Page, M.J.; McKenzie, J.E.; Bossuyt, P.M.; Boutron, I.; Hoffmann, T.C.; Mulrow, C.D.; Shamseer, L.; Tetzlaff, J.M.; Akl, E.A.; Brennan, S.E.; et al. The PRISMA 2020 Statement: An Updated Guideline for Reporting Systematic Reviews. *Int. J. Surg.* 2021, *88*, 105906.
13. Piano Nazionale di Ripresa e Resilienza (PNRR) Italia domani. European Commission. 2021.
14. Nakano, Y.; Tsusaka, T.W.; Aida, T.; Pede, V.O. Is Farmer-to-Farmer Extension Effective? The Impact of Training on Technology Adoption and Rice Farming Productivity in Tanzania. *World Dev.* 2018, *105*, 336–351.
15. Pan, D.; Kong, F.; Zhang, N.; Ying, R. Knowledge Training and the Change of Fertilizer Use Intensity: Evidence from Wheat Farmers in China. *J. Environ. Manag.* 2017, *197*, 130–139.

## PUBBLICAZIONI SU RIVISTA:

- Petrontino, A.; Madau, F.; Frem, M.; Fucilli, V.; Bianchi, R.; Campobasso, A.A.; Pulina, P.; Bozzo, F. Seafood Choice and Consumption Behavior: Assessing the Willingness to Pay for an Edible Sea Urchin. *Foods*. **2023**, *12*, 418. <https://doi.org/10.3390/foods12020418>. (Published: 16<sup>th</sup> January 2023).
- Petrontino, A.; Frem, M.; Fucilli, V.; Tria, E.; Campobasso, A.A.; Bozzo, F. Consumers' purchase propensity for pasta tracked with blockchain technology and labelled with sustainable credence attributes. *Front. Sustain. Food Syst.* **2024**, *8*:1367362. doi: 10.3389/fsufs.2024.1367362 (Published: 14<sup>th</sup> March 2024).
- Frem, M.; Petrontino, A.; Fucilli, V.; De Lucia, B.; Tria, E.; Campobasso, A.A.; Calderoni, F.; Bozzo, F. Consumers' Perceptions for an Outdoor Ornamental Plant: Exploring the Influence of Novel Plant Diseases Diagnostics and Sustainable Nurseries Cultivation Management. *Horticulturae*. **2024**, *10*, 501. <https://doi.org/10.3390/horticulturae10050501> (Published: 13<sup>rd</sup> May 2024).
- Campobasso, A.A.; Frem, M.; Petrontino, A.; Tricarico, G.; Bozzo, F. Classification, Evaluation and Adoption of Innovation: A Systematic Review of the Agri-Food Sector. *Agriculture*. **2025**, *15*, 1845. <https://doi.org/10.3390/agriculture15171845> (Published: 29<sup>th</sup> August 2025)

## MESI DI ATTIVITA' DI RICERCA SVOLTA IN:

- ESTERO presso l'Agricultural University of Tirana - Department of Economy and Rural Development Policy (6 mesi).
- IMPRESA presso LEADER Società Cooperativa Consortile (18 mesi).
- ENTE DI RICERCA presso l'Università degli Studi di Bari – Dipartimento di Scienze del Suolo, della Pianta e degli Alimenti (12 mesi).

## ABSTRACT E ATTI DI CONVEGNO:

- Poster: “Agro-biodiversity valorization paths and farmers' propensity to introduce native



genetic resources". Rizzitiello, F.; Petrontino, A.; Campobasso, A.A., Bozzo, F. Book of Abstract AISSA UNDER 40\_2023, S1 P1. [250472\\_d6ad0973bc5a48b0b8a82cba14b5b795.pdf](https://doi.org/10.250472_d6ad0973bc5a48b0b8a82cba14b5b795.pdf) ([aissaunder40.com](https://aissaunder40.com)) (12-14 luglio 2023).

- Poster: "Methods, tools and theories to measure innovation in the agrifood sector". Petrontino, A.; Campobasso, A.A.; Calderoni, F.; Tria E.; Fucilli V. Book of Abstract AISSA UNDER 40\_2023, S6 P138. [250472\\_d6ad0973bc5a48b0b8a82cba14b5b795.pdf](https://doi.org/10.250472_d6ad0973bc5a48b0b8a82cba14b5b795.pdf) ([aissaunder40.com](https://aissaunder40.com)) (12-14 luglio 2023).
- Contributo accettato al LIX Convegno SIDEA – ID: SIDEA2023\_192: "Methods, tools, and theories to assess the propensity to introduce innovations in the agrifood sector: a literature review". Tria, E.; Campobasso, A.A.; Petrontino, A.; Fucilli, V.; Bozzo, F. (21-22 settembre 2023).
- Contributo accettato al 3<sup>rd</sup> Conference of the European Association of Wine Economists (EuAWE 2024) - ID: 155: "Agrobiodiversity Practices to foster Sustainable Wine Production: Exploring Farmers' Investment Propensity and Drivers". Petrontino, A.; Frem, M.; Tria, E.; Campobasso, A. A.; Calderoni, F.; Fucilli, V.; Bozzo, F. (11-14 giugno 2024).
- Contributo accettato al 3<sup>rd</sup> Conference of the European Association of Wine Economists (EuAWE 2024) - ID: 181: "Analysis of market value and implicit prices associated with the main attributes of Primitivo". Tria, E.; Petrontino, A.; Frem, M.; Campobasso, A. A.; Fucilli, V.; Bozzo, F. (11-14 giugno 2024).
- Contributo accettato al World Symposium IFAMA 2024 – ID: 45142245: "The impact of Blockchain Technology and Credence Attributes on the pasta value chain: An analysis of Italian Consumers' willingness to pay". Petrontino, A.; Frem, M.; Fucilli, V.; Tria, E.; Campobasso, A. A.; Bozzo, F. (17-20 giugno 2024).
- Contributo accettato alla 13<sup>ma</sup> Conferenza dell'Associazione Italiana di Economia Agraria e Applicata (AIEAA): "Xylella fastidiosa invasion: Exploring the Economic and Social Impacts Using Italian Farm Accountancy Network Data". Petrontino, A.; Calderoni, F.; Frem, M.; Campobasso, A. A.; Tria, E.; Sansiviero, C.; Nardelli, L.; Bozzo, F.; Fucilli, V. (20-21 giugno 2024).
- Contributo accettato al 4<sup>th</sup> Conference of the European Association of Wine Economists (EuAWE 2025): "Exploring price determinants of natural wines: A case study on the impact of territorial certification in the Italian online market". Zeka, E.; Di Cosola, F.; Frem, M.; Calderoni, F.; Moramarco, L.; Campobasso, A. A.; Bozzo, F. (14-17 maggio 2025).
- Contributo presentato alla 14<sup>ma</sup> Conferenza dell'Associazione Italiana di Economia Agraria e Applicata (AIEAA): "Fostering sustainable competitiveness: A systematic review of knowledge and innovation adoption in the agricultural sector". Campobasso, A. A.; Bozzo, Tria, E.; Petrontino, A. (18-20 giugno 2025).
- Contributo accettato al LXI Convegno SIDEA: "Conformità normativa e sostenibilità del caffè: un approccio economico integrato". Di Cosola, F.; Petrontino, A.; Giordano, S.; Calderoni, F.; Campobasso, A.A.; Bozzo, F. (2-4 luglio 2025).

## SEMINARI ED ALTRI CORSI EXTRA-CURRICULARI

- Finanziamenti europei e regionali per ricerca e imprenditorialità innovative (Laboratorio di Competenze Trasversali 2022/2023);
- Corso online del Master avanzato in Economia e Politica agraria 2022-2023 dal titolo "Applied Discrete Choice Experiments on Innovative Food Products" (30 ore) – Prof. Asioli (17 - 21 luglio 2023);



Finanziato  
dall'Unione europea  
NextGenerationEU



**Italiadomani**  
PIANO NAZIONALE  
DI RIPRESA E RESILIENZA



**UNIVERSITÀ**  
DEGLI STUDI DI BARI  
ALDO MORO

- Corso online del Master avanzato in Economia e Politica agraria 2022-2023 dal titolo “Q Methodology and the Scientific Study of Subjectivity with Application to Innovations in the Food Sector” (30 ore) – Prof. Zanolì (24 - 28 luglio 2023).
- Short master “Contratti e Imprese nella filiera Agrifood” Terza edizione, a.a. 2023-24 (16 febbraio - 17 maggio 2024);
- Corso online del Master avanzato in Economia e Politica agraria 2023-2024 dal titolo “Farm and farmers behavioural analysis” – Prof. Paparella (02 - 16 maggio 2024);
- Corso laboratoriale di europrogettazione - focus sui programmi Interreg (Laboratorio di Competenze Trasversali a.a. 2023/2024);
- Laboratorio di analisi e presentazione dei dati geospaziali (Laboratorio di Competenze Trasversali a.a. 2024/2025);
- Profili professionali degli studi di genere: l'imprenditoria femminile e l'esperienza della cooperazione (Laboratorio di Competenze Trasversali a.a. 2024/2025).