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Economic and policy analysis of technology uptake for the smart management of agricultural systems

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INTRODUCTION

This special issue of Bio-based and Applied Economics "Economic and policy analysis of technology uptake for the smart management of agricultural systems" stems from the growing diffusion of innovative digital technologies as strategic solutions for the development of the agricultural sector.

Agriculture is undergoing a profound transformation thanks to the integration of new technologies (Vishnoi and Goel, 2024; Aijaz et al., 2025), with a view to the sustainable development of the sector (Norman and MacDonald, 2004; Nica et al., 2025). The combined economic and environmental benefits of technology adoption in agriculture are widely recognized in the literature (Giorgio et al., 2024; Papadopoulos et al., 2025). To illustrate, technologies in agriculture help address current interconnected challenges related to productivity, cost reduction, agri-food safety, natural resource conservation, animal welfare, worker safety, and, more generally, the achievement of sustainable development goals (Castillo-Díaz et al., 2025; Finger, 2023; Basso and Antle, 2020; Musa and Basir, 2022; Sridhar et al., 2023). In this context, technological innovations have enabled significant improvement of various agricultural processes through the introduction of different tools, such as the Internet of Things (IoT), sensors, robotics, drones, blockchain, and artificial intelligence (Sharma and Shivandu, 2024). As discussed by Arraigada and Mac Clay (2025), these tools can either complement traditional technologies (e.g., IoT sensors connected to conventional irrigation systems) or substitute them (e.g., spraying drones replacing a traditional sprayer).

The diffusion of innovative digital tools in agriculture is growing (Shang et al., 2021), but their take up still varies significantly across countries, farm types, and production systems (Eastwood et al., 2019; Rose and Chilvers, 2018; Shepherd et al., 2020). This uneven pattern highlights the need to understand the mechanisms underlying the adoption of these technologies and suggests that digital transformation in agriculture is not just

about technology, but also depends on social structures, institutions, and interactions between networks and governance systems (Roberts et al., 2017; Jia, 2021), as well as farmers' personal attitudes and traits (Deißler et al., 2022).

This special issue contributes to the ongoing debate on how digitalization is reshaping agriculture. Combining behavioral theories, such as the theory of planned behavior (Ajzen, 1991), the technology acceptance model (Davis, 1989), and the unified theory of technology acceptance and use (Venkatesh et al., 2012), with economic and policy analyses, the articles examine in detail the factors that help or hinder farmers in adopting new technologies (Maesano et al., 2025; Cozzi et al., 2025; Moussaoui et al., 2025).

PRESENTATION OF THE SPECIAL ISSUE

The articles collected in this special issue aim to offer a broad and multifaceted view of the dynamics linked to the diffusion of innovative digital technologies in the agricultural sector, considering the behavioral, economic, and political dimensions that influence the intention to adopt them.

Kühnemund and Recke (2025), drawing on the Technology Acceptance Model (TAM) framework, investigate the determinants that drive German pig farmers to introduce AI-based camera systems into livestock production. Their findings indicate that perceived ease of use, openness to innovation, and individual innovativeness are the main factors influencing adoption intention. Concerns about data ownership and privacy, however, play a lesser role in driving behavior. Overall, the authors argue that farmers place significant importance on the reliability and functionality of technology. However, trust and transparency are essential determinants of technology adoption. These findings underscore the importance of user-centered design and clear communication regarding how intelligent technologies are implemented in practice.

Cozzi et al. (2025) conduct a study in the Italian horticultural sector, to analyze the adoption of water-smart technologies. Based on data from a survey of 251 farmers in Italy, using an extended TAM3 framework, the authors find that perceived usefulness and social norms strongly influence adoption intentions. The results also show that ease of use is less influential in driving intentions. Their analysis highlights how social interaction and perceived benefits outweigh usability or socioeconomic characteristics in shaping farmers' behavior. From this perspective, the findings suggest that participatory and peer-learning environments can serve as effective channels to accelerate the diffusion of innovation. The findings are consistent with those of Sabbagh and Gutierrez (2025) and Kühnemund and Recke (2025), both of which emphasize the key role of social capital in linking technological potential to actual behavioral change.

Sabbagh and Gutierrez (2025) extend the Unified Theory of Acceptance and Use of Technology framework to analyze the adoption of Agriculture 4.0. The authors identify the main determinants of adoption by comparing marginal and non-marginal areas. Their findings reveal that facilitating conditions, such as access to infrastructure and technical support, and social influence are the main predictors of adoption. Furthermore, according to the study's findings, perceived performance risks have been shown to be barriers to adoption. The authors conclude that adoption intentions depend not only on individual motivation, but also on social and territorial structures that enable knowledge exchange and reduce perceived risk. These findings echo previous work on the rural digital divide, highlighting the need for context-specific policies (Rose and Chilvers, 2018; Eastwood et al., 2019).

Timpanaro et al. (2025) contribute to the literature debate by analyzing the methods of introducing digital tools and their effects in Sicilian citrus farming. Using a Living Lab approach, the authors demonstrate that digital technologies can increase yield per hectare, improve profitability, and enhance water efficiency on citrus farms. Their findings also indicate that participatory innovation processes promote knowledge exchange and collaboration, helping to reduce farmers' resistance to change. The study highlights the need for targeted training and institutional support to ensure that digitalization is effective and inclusive. This participatory perspective resonates with the call for innovation ecosystems that integrate technology into local socioeconomic contexts and sustainability goals.

Maesano et al. (2025) examine the factors influencing Italian consumers' intentions to purchase organic pasta traced using blockchain technology. Extending the Theory of Planned Behavior (TPB) framework (Ajzen, 1991), the authors assess the potential of blockchain in preventing and detecting food fraud. Their findings suggest that subjective norms, perceived behavioral control, and attitudes toward technology are the main predictors of purchase intention, while trust in traditional quality certifications plays a limited role. Therefore, consumers place greater trust in digital traceability tools than in conventional certification systems. However, from a consumer perspective, uncertainty remains about the practi-

cal benefits of these technologies, highlighting the need for a credible and transparent environment in which innovation provides clear added value.

Pacciani et al. (2025) evaluate digitalization levels, perceived benefits, needs, and barriers on a sample of 1,248 Italian farms. The results show that monitoring systems and connected machinery are the most used technologies. In addition, efficiency gains in farm and production management, improved operational control, and perceived benefits are key drivers of adoption, while financial and structural limitations remain significant obstacles. The authors call for coordinated policy measures to support the digital transition, combining advisory services, investment in infrastructure, and human capital development. Their conclusions are consistent with those of Sabbagh and Gutierrez (2025) and Timpanaro et al. (2025), who also emphasize the importance of governance coordination, training, and connectivity in promoting technology diffusion.

Moussaoui et al. (2025) employ a mixed-methods design, combining surveys and in-depth interviews to gather stakeholder perspectives on smart agriculture technologies and their policy integration. The results of the study show a broad agreement on the potential of technologies to improve agricultural efficiency, sustainability, and productivity; nonetheless, it also identifies persistent barriers, including high upfront costs and limited technical expertise. The authors highlight the need for financial incentives, capacity-building initiatives, and stronger infrastructure to encourage adoption. The conclusion of this study supports adaptive, multi-level governance frameworks that link top-down policy design with bottom-up innovation processes to ensure greater policy coherence. In line with Pacciani et al. (2025), their findings reinforce the view that digital transformation depends as much on systemic governance reform as on technological progress.

Finally, Arraigada and Mac Clay (2025) expands the geographical scope with an exploratory study of digital agriculture (DA) start-ups in Argentina, providing comparative insights from the Global South. The paper discusses the interactions between the established agricultural input industry and 114 DA start-ups based on two technological dimensions: embodied/disembodied technologies and complementary/substitutive. Overall, the analysis shows that most of the solutions developed by Argentine start-ups tend to be complementary to the existing technological packages, and this may represent an opportunity for dominant firms to strengthen their position either by acquiring or investing in early-stage start-ups to incorporate those solutions into their own technological platforms.

CROSS-CUTTING INSIGHTS AND POLICY IMPLICATIONS

This special issue offers different perspectives on the dynamics of technology adoption and the governance of digital transformation in agriculture. The evidence confirms that technology adoption is not merely a technical or economic process (though these aspects are very important), but it is a socio-institutional transition, that depends on mental constructs, social norms, and collective learning mechanisms, and is strongly influenced by the external conditions in which innovations are embedded. Behavioral models indicate that perceived usefulness and social influence are the main determinants of farmers' acceptance of innovations. Conversely, perceived risk, high costs, and institutional uncertainty remain the main barriers.

From a policy perspective, the findings highlight that monetary incentives alone will not ensure a successful digital transition unless they are part of coherent and flexible governance arrangements that align public and private resources, promote interoperability, and leverage synergies within the sector (Wolfert et al., 2017; Klerkx et al., 2019; Viaggi, 2019). The articles in this special issue suggest that effective strategies must combine investment with the development of digital infrastructure and educational programs to build long-term innovation capacity. More generally, the integration of behavioral and economic policy analysis in these articles demonstrates how interdisciplinary science can inform evidence-based solutions to ensure the deployment of smart technologies in the context of resilient agri-food systems.

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This Special Issue also saw the participation of our colleague Maurizio Canavari, who passed away prematurely at the beginning of 2025, far too soon. He was a curious, generous, and committed scholar, deeply engaged in the fields of agri-food economics and consumer behavior. His collaborative spirit enriched all those who had the privilege to work with him. Maurizio

contributed to the conception, design, and realization of one of the studies included in this Special Issue, namely Cozzi et al. (2025). He leaves an indelible memory among his colleagues and students.

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