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AN ECOSYSTEM APPROACH TO IOT ADOPTION IN AGRICULTURE: A MULTIPLE-CASE STUDY

TREO Paper

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Abstract

In this TREO paper, we present preliminary findings from our ongoing research on the adoption of the Internet of Things (IoT) technologies within the agricultural sector. The study is based on multiple exploratory case studies in four countries (Greece, Italy, Serbia, and Türkiye). These cases show how the diffusion of IoT innovations unfolds within diverse geographical, socio-economic, and legal contexts. Our preliminary findings underscore the early stage of the innovation ecosystem formation within the IoT market for agriculture, which is often fragmented, loosely coupled, and ephemeral. This necessitates that companies strategise effectively, aligning their approaches with the evolving and, in some cases, yet-to-emerge IoT ecosystem to ensure the success of their IoT-driven agricultural ventures.

Keywords: Internet of things (IoT), Smart agriculture, Innovation ecosystem, Multiple case study

1 Introduction

Internet of Things (IoT) has emerged as the linchpin in the digital transformation of agriculture, facilitating the shift from mechanisation to digitalisation. The commercial potential of digitalisation in this untapped sector has engendered a modern-day "gold rush." Established industry players and global technology corporations, along with numerous start-ups, have embraced the opportunity to introduce various IoT solutions to the farming community (Birner *et al.*, 2021), often under the banners of "Smart Agriculture" or "Precision Agriculture".

Despite the maturity of IoT technologies and the strong push by business and government entities, the adoption of IoT innovations by farmers continues to present a formidable challenge (Chakravorti, 2004). According to a recent study by Bulut and Wu (2023), the majority of current commercial IoT initiatives in agriculture are confined to either protected indoor farming practices or the production of "high value" agricultural products, such as viticulture, aquaculture, and livestock. In stark contrast, traditional outdoor agriculture, upon which the global population heavily relies for staple crops like wheat, rice, and maize, lags considerably in terms of IoT adoption. This discrepancy is observed not only in developing countries with limited infrastructure but also on a global scale. Furthermore, many ongoing IoT endeavours in agriculture are financially supported by public sector entities, a model that is unlikely to be sustainable over the long term.

This research is a response to the call made by prior studies, such as Bulut and Wu (2023), which advocates for a systematic investigation of IoT diffusion strategies in agriculture. While existing research acknowledges the significance of IoT-based business models for agriculture (e.g., Birner *et al.*, 2021), limited scholarly attention has been dedicated to this area. Existing efforts to define and develop IoT-based business models have largely provided tools (e.g., Athanasopoulou *et al.*, 2018) or blueprints (e.g., Leminen *et al.*, 2020) under the presumption of an existing ecosystem, yet they do not elucidate the practical means by which these models can be effectively implemented—specifically, how IoT

products can be adopted by farmers in the field within the current market conditions, particularly within an innovation ecosystem that is still in its nascent stages or yet to fully manifest.

The primary objective of this study is to provide empirically derived insights from field experience to help surmount the significant barriers to IoT adoption within the context of outdoor agriculture. We depart from the conventional technology acceptance and diffusion literature where innovations are characterised in terms of “perceived usefulness” or “perceived relative advantage” (Markus *et al.*, 2008). Instead, we examine organisational conditions, market enablers and constraints, and the complex dynamics in the IoT ecosystem in order to understand the success and challenges of IoT diffusion in agriculture. In line with this objective, our study seeks to address the following pivotal research question: *In the context of present market conditions, especially within an emerging innovation ecosystem, what strategies and mechanisms can facilitate the widespread adoption of IoT in the agriculture?*

2 Methodology

This empirical study employs an exploratory multiple case study design to capture the complex dynamics in the early stages of IoT ecosystem formation in different local contexts which enable or hinder the diffusion of IoT in agriculture. IoT-product based companies are the target population for case studies, who possess first-hand knowledge as they collaborate daily with farmers and other key stakeholders from both the public and private sectors, while concurrently running viable businesses that must contend with various barriers.

Using a mix of purposive and snowball sampling, we carefully selected potential cases among the companies with both the similarities and differences to support an effective cross-case comparison. The current study comprises six case companies from four countries, selected in accordance with the study's scope, which meet the criteria of engaging with end users (farmers or producers), and offering IoT-based products or services tailored for outdoor agriculture applications, such as irrigation and remote sensing. Data collection predominantly involves semi-structured, in-depth interviews conducted in person whenever feasible. These interviews encompass a range of participants, including managers, executives, professionals representing the participating case companies, as well as their customers and other relevant stakeholders. The interview process is designed to align with the qualitative research approach. There are a set of key questions in an open-ended format that might be adapted and complemented with additional questions during the interview.

3 Preliminary Findings

Our initial findings illustrate how business strategies are formulated and dynamically adapted within the context of the existing innovation ecosystem while considering the external conditions for adoption of innovations in the market. Although the majority of interviewees were not able to provide a clear and complete picture of the innovation ecosystem in which they operate, they have provided valuable insights that highlight its pivotal role in shaping their strategic decision-making, ranging from product development to go-to-market endeavors. For instance, DunavNET, headquartered in Serbia, has cultivated a network of partners encompassing hardware providers, system integrators, telecom operators, and local consultants, who provide “a connection between us and the farmers,” Srđan Krčo, CEO of the company says. “We offer complete turnkey solutions, and we wouldn’t be able to do that without partners. “We created our ecosystem,” Spasenija Gajinov, the product manager of the company adds. “agroNET has been created in collaboration with researchers from universities, agronomists, and other agricultural consultants who have been in the business for twenty years,” she says. “People who are part of agricultural production with their knowledge and expertise. We use and digitise their knowledge on our platform.”

Our research indicates variations in the maturity of innovation ecosystems and the roles such as enablers or leaders, assumed by different actors within each country under investigation. For example, the government is viewed as an enabler and catalyst for market development. “I would say that without the government this market would not exist,” Andrea Galante, CEO of Primo Principio says, highlighting

role of government support for the survival of the market in Italy. Conversely, in Türkiye, government intervention was noted to potentially impede innovation by the research participants. “In fact, there are a lot of difficulties in flying drones because the ecosystem is not fully formed... Since the ecosystem has not been formed, everything is new,” Prof. Gündoğdu says. Furthermore, our findings underscore the nuanced impact of government incentives, which may not always yield the anticipated outcomes. Theocharis Moysiadis, the product owner at Future Intelligence in Greece, highlighted the sector's heavy reliance on subsidies, noting that while government-supported programs aim to stimulate market activity, they can inadvertently create barriers to commercialisation. “Government supported programmes I also must say... creates a barrier for us... the product they are interested in... but they know that... a [new] programme will open. And, yeah, I start to wait for the government to pay for it... So the duration to the real sales is much longer..”

These exemplary quotes indicate the dynamic and evolving nature of the innovation ecosystem in the IoT market within the agricultural sector. There are variations in the maturity of IoT ecosystems and the innovation roles such as enablers or leaders, assumed by different actors within each country. IoT companies are required to align their strategies with this evolving ecosystem and make adjustments as necessary. The diffusion of IoT technologies in agriculture, therefore, requires constant tuning of boundary resources (Eaton *et al.*, 2015) and organisational capabilities to capture co-created value in the IoT ecosystem (Schrieck *et al.*, 2021).

4 Next Steps

It is essential to note that the findings presented in this TREO paper are derived from interim data analysis and remain subject to refinement. Our research is ongoing, and further interviews are currently in progress. In the next few months, prior to ECIS 2024 in June 2024, we aim to finalise all interviews and conduct a comprehensive analysis of the gathered data towards theory development. The outcome of this research is also expected to yield a framework designed to provide guidance IoT practitioners in selection of appropriate adoption strategies in the context of outdoor agriculture.

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