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Exploring digitalization in the agricultural industry: barriers, enabling factors, and impact of digital technologies adopting

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Exploring digitalization in the agricultural industry: identifying barriers, enabling factors, and findings of digital technologies adoption

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Abstract. Digital transformation (DT) changes business organizations by introducing innovations in all sectors, including agriculture. Organizations in the agricultural industry have been implementing DT for different forms of innovation. As a result, over the years, several studies explored the adoption of digital technologies in the agricultural industry, mainly focusing on the practical and applicative side of digital technologies and exploring single cases in which DT contributes to organizational and operational change. A holistic perspective of DT in the agricultural industry is still lacking in the literature, and barriers, enablers, and findings of DT in agriculture are not present in the literature. In this paper, we present the results of a literature review to identify barriers, enabling factors, and findings of DT in the agricultural industry.

Keywords: Digital transformation, Digitalization, Agricultural industries, Digital Technologies

1 Introduction

DT is a driver of improvement in industries, leading to increased productivity and improved opportunities for value creation. In recent years, several industrial sectors have initiated a transformation process using digital technologies to improve operations and exploit new forms of cooperation with stakeholders [1]. Among the various industrial sectors affected by DT, agriculture was also affected by DT. In this paper, we consider the agricultural sector as composed of the agri-food chain, including all activities involving producing agricultural products and animals directly in the fields and on farms [2]. DT in agriculture affords organizations to obtain real-time information on weather conditions, soil nutrient requirements, and other data useful for tillage and breeding. These data sources give agricultural industries greater production efficiency, less wasted inputs and pollution, and higher profitability [3].

The use of digital technologies in agriculture leads to the development of the concept of smart farming [4]. Smart farming literature explores a wide gamut of advanced digital technologies adoption in agricultural industries, such as the Internet of Things, Big Data, wireless sensor networks, and Blockchain, used interconnected in different scenarios [6]. For instance, IoT integrates digital technologies for monitoring moisture,

soil temperature, or plant diseases. Such infrastructure requires a wireless sensor network that collects data and sends it to a cloud repository affording digital monitoring [1]. Such infrastructure produces big data, i.e., data of large volume, variety, voracity, velocity, and veracity of the various activities of the agricultural industry. Cloud-based technologies are used both to store and analyze big data. Big data analysis helps agricultural business organizations diagnose problems, explore solutions, and improve. As a result, of such digital technologies applications, agricultural industries achieve the benefits described before [3].

The potential benefits of similar applications of digital technologies in agriculture can be manifold, but adoption by farmers is frequently superficial [9]. Over the years, several studies explored the adoption of digital technologies in the agricultural industry, mainly with case studies focusing on the practical and applicative side. In this paper, we aim to progress literature by exploring barriers, enablers, and findings of DT in the agricultural industry holistically through a literature review. We will investigate the following research questions in this study:

RQ1: What is the state of the art of digitalization in agricultural industries?

- *RQ1.1: What are the barriers limiting the adoption of digital technologies in agricultural industries?*
- *RQ1.2: What are the enabling factors for adopting digital technologies in agricultural industries?*
- *RQ1.3: What are the impacts of adopting digital technologies in agricultural industries?*

This paper is structured as follows. Section 2 defines a theoretical framework of DT in the agricultural sector. Section 3 introduces the methodology used to conduct the literature review, and in section 4, we present the findings. In section 5, we introduce the discussions, and finally, in section 6, we include the conclusions and implications.

2 The theoretical framework of digital transformation in the agricultural industry

Literature reports that different conceptualizations of DT in agricultural industries exist in the literature. Early applications of digital technologies to agriculture started in the 1990s and went down under the name of *precision agriculture*. In precision agriculture, digital technologies monitor soil and crop conditions and define appropriate treatments to improve resource utilization and increase profits. With the advent of DT, *smart farming* emerged in the literature to indicate new problems and solutions for the digital management of agricultural industries [5]. Smart farming is the application of modern digital technologies in agricultural industries that enable the collection of big data that industries, farmers, and third parties can analyse and subsequently use to make decisions that can improve agricultural industries. Proper information management makes it possible to compare similar situations across different agricultural industries to achieve effective solutions from other perspectives.

Of course, smart agriculture has specific characteristics related to the use of technologies and the need for skills that enable digital technologies. People working in industries need specific skills through which industries can begin to use digital technologies. One of the main goals of using digital technologies is the need to train qualified personnel or retrain those already in the organization [15]. According to Masud et al. [16], smart agriculture helps farmers manage field and crop information, solar radiation, and efficient land use through proper management of information and livestock. Through digital agriculture, it will be possible to meet future challenges related to the problem of food and the sustainable and intelligent management of digital technologies. Digital agriculture will generate significant changes in the industry by integrating modern digital technologies and replacing traditional techniques with innovative and automated methods. With digital technologies, farmers can gather data, information, and knowledge to use in making agricultural decisions [2, 6, 9, 14, 17–23]

3 Methodology

Our article aims to analyse DT in agricultural industries, identifying the barriers, enablers, and findings of digital technology adoption. We conducted a literature review [25], searching information in the SCOPUS database because it contains a high coverage of analyses and citations compared to other sources [14]. The search includes scientific publications published in journals up to November 2021, all in English and the section "Business, Management and Accounting". We chose the subject area "Business, management, and accounting" because it is akin to our research objective.

In Table 1, we identified the literature relevant to our research question using a stepwise selection process, considering the search criteria described above.

Table 1. - Summary of the literature review process

Item	Description
Search in select database	3170
Evaluate title, abstract, and keywords	276
Review full text	210
Forward and backward search	15
Total number of scientific articles	47

We developed a specific research query to identify all publications regarding digital transformation in the agricultural industry. The results of the research produced 3170 articles. To search for information useful for our research, we initially did a preliminary reading of the abstract and title, thus selecting the most useful articles for the research. Subsequently, we read all previously selected articles to check whether they contained information useful for our research. We filtered all articles to check that they contained keywords such as “agriculture”, “digitisation”, “digital transformation” and “information system” in the title and abstract. The keywords chosen were related to our research objective. Finally, we selected only the most relevant articles for our research.

Relevant articles are those selected through inclusion and exclusion criteria. We considered all papers in the literature review to identify barriers, enablers, and impacts of digital technology adoption. From the empirical case, we identified all the elements that often represent the constructs of information systems theories. We then extrapolated all the variables present in the studies and classified them into three groups, considering their nature. While reading the papers, we conducted a backward analysis to detect important papers for our research to extrapolate variables. We created a conceptual article matrix to summarise the articles identified by the review process. Relevant articles are those selected through inclusion and exclusion criteria, such as considering only articles from leading scientific journals, using specific keywords in the search, analysing citations in the papers, and attempting to identify the impact of the technology on the agricultural sector. While reading the papers, we conducted a backward analysis to identify important documents for our research. We created a conceptual matrix of the articles, in which we summarized the information identified in the review process, grouping the concepts into units of analysis for easy presentation. After collecting the constructs, we analysed them to determine whether they were barriers, limitations, or achievements resulting from adopting digital technologies. One validity criterion is factor extraction, where an author has read the entire literature and coded the information. Both authors discussed the results of the coding. We repeated several rounds of coding and discussion until both authors agreed on the review process results.

4 Findings

In this section, we describe the findings from the literature review and provide a specific description of the database and answer the research questions.

4.1 Descriptive analysis of database

In Figure 1, we see that the year with the most publications is 2020 (23 papers, 49% of sample), followed by 2021 (9 papers, 18% of sample), and finally, 2019 (5 papers, 11% of sample).

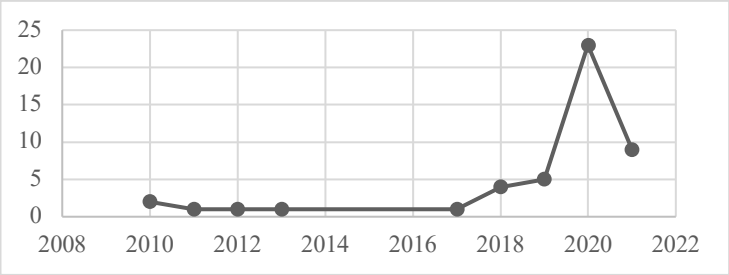

Fig. 1. Year of publication

Source: our elaboration

4.2 Barriers, enabling factors, and findings of digital technologies adoption

The study's results identify the creation of three different groups of factors extrapolated from the literature review to identify the enablers, barriers, and findings of digital technology adoption in agricultural industries. First, we extrapolate all the factors found in the literature, which will then be divided into groups. Often some of the factors present in the empirical studies are part of specific and already established information systems theories, such as the Technology Acceptance Model (TAM) [26], the Unified Theory of Acceptance and Use of Technology (UTAUT) [27] or the Resource-Based View (RBV) [28].

As these factors are already defined, they are often supplemented with new factors to study different objectives. Extrapolating all factors, including those from the already defined models, we tried to divide the variables into three groups: enabling factors, barriers, and digital technology adoption findings. Enabling factors enable individuals to promote technical and organizational infrastructures using digital technologies [29].

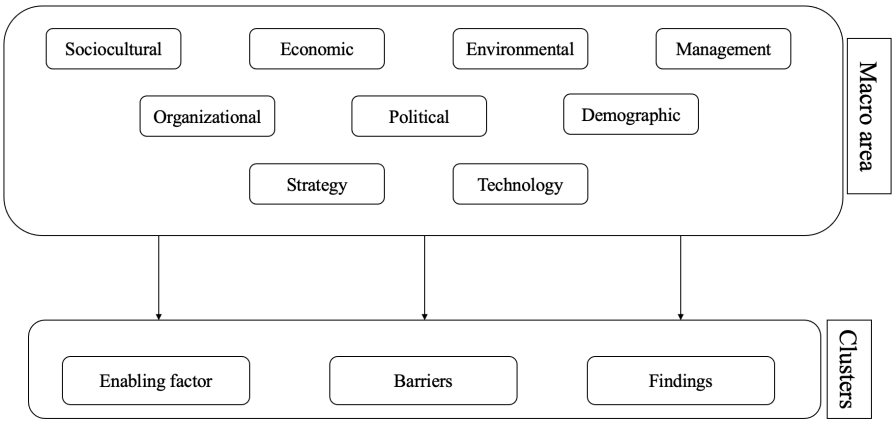

Fig. 2. Description of clusters and macro areas

Source: our elaboration

In the following sections, we present in detail the three clusters identified because of the literature review analysis, seeking to specify, for each group, the variables that constitute it. Each group has its characteristics depending on the type of variables contained, and above all, they have different objectives.

4.2.1 Barriers

We analysed and classified variables extrapolated from papers representing barriers to adopting digital technologies in agriculture to answer the first research question. These variables include the *complexity of technology use*, i.e., digital technologies are

often not used because people within the organization lack specific skills and knowledge. The lack of these elements limits the adoption of digital technologies. Often farms continue to use traditional farming practices [14, 30]. Another barrier is the *government's subsidies* to industries that use them to purchase digital technologies. The government's lack of subsidies is one of the most significant barriers. To overcome this barrier, the government can define strategies promoting entrepreneurship in agricultural industries. Governments may decide to finance investments in agricultural industries by providing funds to promote purchasing new infrastructure and knowledge to create innovative business models [14]. Through investments granted by the government, agricultural industries can also innovate the infrastructure they already own [6, 14, 15]. The decision to adopt digital technologies and acquire financing will depend on the return on investment improved by agricultural industries [31]. Incentives depend on developing opportunities offered by norms and standards available internationally, linked, and coordinated with national reference strategies[2, 9, 32]. The farmers are reluctant to use digital technologies in this group of important variables. Farmers often take a *nervous attitude* when the industry introduces digital technologies because they might cause problems during work. [33]. Farmers represent the category of non-adopters and have a *non-adopting behaviour*, which depends on several issues and risks that the agricultural industry may encounter. The risks mainly concern the failure of the industry [34, 35].

Farmers represent the category of non-adopters, and their non-adoption behaviour depends on various problems and risks that the agricultural industry may encounter. The risks mainly relate to the failure of the industry [32, 33]. In this case, defining what we mean by a farmer is important. According to [36], farmers are all those active part or full time in various activities that depend on the type of agricultural industries, such as cultivating the land, growing crops, or raising animals. The farmer can also be an entrepreneur, called an agricultural entrepreneur, in which he or she manages the agricultural industry by trying to expand his or her business and managerial skills to achieve the set goals [37].

Defining the agricultural entrepreneur, however, is difficult because his activities differ from simple business activities. The agricultural entrepreneur has different dynamics and behaviour than other businesses, as he/she could be the owner, a tenant, a manager, or a combination of several. For this reason, the methodologies used to define the entrepreneur in other sectors are not easily transferable to the agricultural entrepreneur [38]. Considering the previous concepts, farmers may decide not to use digital technologies because they could bring *significant organizational changes* that do not meet the expected needs [35].

4.2.2 Enabling factors

We identify these enabling factors because there are no studies in the literature that explicitly show the enabling factors that allow individuals to promote the adoption of digital technologies in agricultural industries [1, 29].

We find *social aspects, skills, and capabilities* of individuals and, respectively, the *motivation of farmers* to use digital technologies in industries [14, 31, 39]. Other elements concern the *ease of use* and *farmers' perceptions* of digital technologies. Many of these identified variables derive from information systems theories, which identify attributes that condition the adoption of digital technologies in the agricultural industry. These variables are present in the enabling factors and the findings of technology applications. [1, 5, 9, 19, 30, 35, 40–43]. Among the social aspects, *demographic characteristics* are another key condition for adopting digital technologies in agricultural industries because they include all enabling factors that can influence the decision-making process [33]. Adoption by the industry depends on *research and development* conducted to refine the digital technologies to generate easy implementation solutions. Implementing digital technologies requires *highly skilled personnel* with skills related to digital tools and skills in organization, processing, and analysis [15]. This cluster's enabling factor aims to motivate farmers of agricultural industries to adopt digital technologies and gain a competitive advantage. It is necessary to *incentivize farmers* to use digital technologies by identifying the benefits they can generate. The impact of smart farming regards as improving farm profitability and productivity [14, 16, 23], optimizing management to make wise and successful management decisions [6, 16, 23], preventing environmentally [14], improving the relationship among farmers, industries, and stakeholder [6], reduce losses and costs [6, 16, 23], increase business efficiency [23], and collect and aggregate information about the production [6].

When the industries or farmer understands the benefits associated with the use of digital technologies, he or they may decide to implement them.

4.2.3 Impacts on digital technologies adoption

Finally, we have identified the variables that represent the impacts resulting from the adoption of digital technologies in agricultural industries. Digital technologies change the organization of *business processes*, which leverage business technologies to improve business agility [7, 30, 41].

Business performance depends on the use of digital technologies that enable the achievement of goals by attracting the use of available and shared data and information [1, 23, 32, 44]. *Data and information* are important for positive business performance and cost-effective decisions [8, 9, 45]. The information gathered with digital technologies can cover different aspects, such as agronomic practices, e.g., sowing, fertilizers, pests, irrigation or crops, or marketing. With useful information for farmers, decisions are made based on awareness of past events [46, 47].

Adopting digital technologies *automates production-based processes* in the field, such as crop irrigation and soil quality [6, 23, 30], but can also generate better revenues and profits [48].

The optimal use of digital technologies in the agricultural industry also depends on *profitability* [6, 14, 45].

The use of digital technologies makes it possible to identify specific areas suitable for cultivation due to *production efficiency*. The agricultural industry with skills differ-

entiates itself and improves its *competitive advantage* using operational resources gathered through digital technologies [29]. *Coordination between farmers and employees* to establish training programs and economies of scale is important [9]. Digital technologies are key elements of modern agricultural industries because they enable the rapid exchange and perception of information, identifying challenges and changes [41]. Digital technologies replace or complement the *capabilities of the individual* in performing certain activities [42]. Therefore, adopting digital technologies generates convenience for the industries that decide to adopt them and for their use [1, 29]. To implement digital technologies in businesses, *compatibility with the activities* performed is necessary. For this reason, compatibility is another very important enabling factor. The enabling factor makes it possible to identify methodologies to promote innovation in industries, reducing all measures incentivizing not to use digital technologies [30].

5 Discussion

The literature review identified the concept of digitalization in agricultural industries called smart farming or Agriculture 4.0, digital agriculture, e-farming, and precision agriculture. There is no shared definition of the smart farming concept. Still, we can say that identifying the application of digital technologies in agricultural industries reduces environmental impact, improve business performance, and reduce cost. Smart farming identifies an evolution of agricultural production systems because digital technologies can digitalize, visualize, design, monitor, and control agricultural processes and products. Smart farming is very important because it helps farmers manage the production process and decide, thanks to digital technologies that collect data and information and process them [2, 5, 6, 9, 14, 16, 19–23].

Digital technologies in agricultural industries provide the best subsistence practices and enable the improvement and achievement of business goals [48]. Through digital technologies, agricultural industries can manage the risks, analysing the farmer's perception and offering effective solutions [31]. Since digital technologies in agricultural industries provide many benefits, it is important to identify the enabling factors, barriers, and findings of applying technologies. Our work identified all the variables analysed in the empirical cases and classified them, following a careful analysis of the articles into three clusters: enabling factors, adoption barriers, and adoption impacts.

By extrapolating the variables used in the case studies identified in the literature review, we attempted to classify these variables into three different clusters: enabling factors, barriers, and technology adoption findings. The classification of variables, obtained through careful reading and analysis of the articles, identified the presence of many variables. Many articles follow a theoretical basis in their investigations to test the adoption of digital technologies in business. The commonly used theories include organizational capability theory, innovation diffusion theory, social network theory, technology acceptance model, Unified Theory of Acceptance and Use of Technology, Resource-Based View, and Expectation Theory [1, 5, 9, 19, 30, 40, 43, 49–51]. During the variables' classification, some confused the type as they could be assumed to impact technology adoption and enabling factors. The classification difficulty stems from their

definition, so we decided to classify them according to their context. The three variables are not the only ones that confused their classification, but their presence was much more relevant than other variables because they are variables in information systems theories.

Classifying other variables was easier because the definition clarified where they belonged in the reference cluster. We can answer the research questions by dividing the variables into three groups. The variables classified as barriers represent the elements limiting digital technologies' adoption in agricultural industries. In detail, these variables are negative for industries because they do not have the need, especially the intention to adopt digital industries. The cluster of enabling factors includes all variables that characterize and influence the adoption of digital technologies in agricultural industries. Enabling factors are very broad. They have variables related to various contexts, such as social and technological. There are already studies analysing existing enabling factors for adopting specific digital technologies, such as IoT[1], or others analysing the willingness of farmers to adopt digital technologies [5]. This analysis identifies and classifies the enabling factors needed to adopt digital technologies in agricultural industries. Finally, the last cluster comprises all the variables representing the impacts of adopting digital technologies, mainly showing the benefits that digital technologies bring to the agricultural industry.

According to the analysis, the variables that make up the barriers cluster coincide with the study by [52], who identified digital technology adoption barriers. Barriers concern internal factors within the industry, such as people's skills, and external factors, such as political elements, influence the adoption of digital technologies. The variables included in the clusters of enabling factors and digital technology adoption findings are also in line with [53], which identifies all the possible effects and factors influencing the adoption of digital technologies in agriculture. The model will have to consider these three interlinked clusters. Looking at the macro-areas used for a clearer and simpler understanding, we see that each macro-area has barriers, enabling factors, and the findings of digital technology adoption. Some areas, such as sociocultural, strategy, and technology, are more numerous than others. These contain a larger number of variables than the others. There are fewer environmental, political, and demographic variables in other cases.

Future research needs to continue investigating clusters to build a model that can explain how digital technologies adopted in agricultural industries affect agricultural industries, considering barriers limiting adoption, enabling factors, and the findings of digital technology adoption.

6 Conclusion

Our article aims to identify the barriers, enablers, and findings of the application of digital technologies in agriculture. Through a literature review, we first determined the context of DT in agriculture, including the digitization phenomenon through the implementation of digital technologies, identified as smart farming. After this analysis, we have identified the three groups that make it possible to analyse the barriers that limit

the use of digital technologies in agriculture, the enabling factors to incentivize digital technologies, and finally, the impacts that industries manage to achieve the usage of digital technologies. The variables identified in the literature review are more numerous. The repetition of variables depends on using the same theories during the studies. Even though sustainability is an important issue that cuts across agricultural industries, the analysis did not identify any variables that study this concept.

For this reason, it might be interesting to carry out studies that analyse the impacts of sustainability on the adoption of digital technologies in agricultural industries. Future research needs to continue investigating clusters to build a model that can explain how digital technologies adopted in agricultural industries affect agricultural industries, considering barriers limiting adoption, enabling factors, and the findings of digital technology adoption. The model will have to consider these three interlinked clusters.

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