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Digitalization of Agri-Cooperatives in the Smart Agriculture Context. Proposal of a Digital Diagnosis Tool

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Abstract: The use of digital technologies has been recognized as one of the great challenges for businesses of the 21st century. This digitalization is characterized by the intensive use of information technologies in the different stages of the value chain of a sector. In this context, smart agriculture is transforming the agricultural sector in terms of economic, social, and environmental sustainability. In some countries, cooperatives, as the most common legal form of the incumbent companies, in this rather traditional low-intensive technology sector, are going to develop a relevant role in the process of adoption of these technologies. In this context, this paper provides, first, a review of the evolution of the main digital technologies, such as Internet of Things, robots, Artificial Intelligence, Big Data, and Blockchain, among others. Second, a description of the digital innovation process in agri-cooperatives in order to help them in the decision-making process, and third, a digital diagnosis tool for measuring cooperatives' digital innovation. This tool is initially applied to two cases of agri-cooperatives in Spain. All of this contributes to a better understanding of digitalization of agri-cooperatives in the context of smart agriculture.

Keywords: digitalization; digital transformation; smart agriculture; cooperatives; digital diagnosis tool

1. Introduction

In the current context, environmental factors are increasingly dynamic and unpredictable, giving rise to the problem of businesses maintaining their competitive advantages in turbulent environments [1,2]. Thus, businesses must modify their resources to adapt quickly to changing conditions if they want to maintain their competitive advantage over time [3,4]. Consequently, they must be agile and this agility requires processing a large and varied amount of information that must not only be processed and interpreted but also generated, managing Information Technologies (IT), for example, the recently developed Blockchain [5].

In fact, technologies are present in the day-to-day life of people and organizations and this has been growing exponentially in the last years, in a way that authors like Rifkin [6] refer to as a new industrial revolution and others describe directly as a Fourth Industrial Revolution or Industry 4.0 [7]. Although the phenomenon of business digitalization can be considered relatively recent, academic research in that field has a certain path, and authors such as Bughin and Chui [8], Brynjolfsson et al. [9], Günther et al. [10], or Akoka et al. [11] have addressed the issue. This digital transformation is based on the intensive use of IT in the search for competitive advantages or, at least, on the intention of remaining in the market imitating the most innovative competitors. In fact, the intensity and use of digitalization can become a factor of differentiation just as has happened historically when innovations have been introduced, with the capacity of transforming sectors completely, and every company needs to respond to this challenge [12].

In addition, in the case of the agricultural sector, technologies such as Internet of Things (IoT), robots, Artificial Intelligence (AI), Big Data (BD), and Blockchain, among others, are affecting the complete value chain, from input suppliers to the consumers [13,14].

The implementation of digital technologies is helping to reduce water and pesticide use, is fostering food safety by tracing unsafe food quickly, and is developing new businesses and new jobs, improving economic, environmental, and social sustainability. First, these technologies have relevant economic impacts, creating new jobs or businesses and improving the competitiveness of established companies (economic sustainability). Second, in terms of climate or habitat issues, such as precision farming systems for reducing the use of water and pesticides, the use of these technologies is improving environmental sustainability. Third, in terms of social issues, they are helping to develop some rural regions with a poor population (social sustainability). Therefore, these technologies are transforming the sector towards a smart and more sustainable one, cooperating also in the fighting against climate change [15]. The concept of this smart-agriculture is related with at least five sustainable development goals of the United Nations: Goal 8: Decent Work and Economic Growth, Goal 9: Industry, Innovation, and Infrastructure, Goal 11: Sustainable Cities and Communities, Goal 12: Responsible Consumption and Production, and Goal 13: Climate Action.

In this work, the focus is on the consequences of digitalization, offering a tool that helps agricultural cooperatives (agri-cooperatives) to know what place they occupy in relation to the digital transformation process that all productive sectors are experiencing. In the field of agricultural cooperativism, there are interesting works related to this theme. For example, Rodenes and Torralba [16] proposed new technologies as tools that enhance organizational learning and improve knowledge management in cooperative societies. Similarly, Vargas [17] analyzed the ownership structure of cooperatives and how they obtain competitive advantages based on the effective use of IT. In addition, other specific studies have been conducted in the cooperative olive sector [18,19].

In the case of this research on agri-cooperatives, first, the context of the digital transformation is described as well as the basic IT-related concepts (IoT, AI, BD, and Blockchain technology). Second, from this analysis, arises the identification of the technologies and factors that integrate the auto diagnosis instrument, named Agri-Cooperative Digital Diagnosis Tool. This tool allows a self-assessment of the situation in which the cooperative is, in relation to the digital transformation, helping cooperatives to understand the possibilities that the digital technologies offer. Two cases of cooperatives are analyzed as an initial exploratory application. All of this contributes to a better understanding of digitalization of agri-cooperatives in the context of smart agriculture. In addition, this paper reveals to public stakeholders the relevant role of the agri-cooperatives in the development of the smart agriculture, and how their support is needed to transform the sector and help to develop global sustainability for preserving the environment [20].

2. Digital Transformation: towards Agricultural Smart-Cooperatives

2.1. The Digitalization Process

Digitalization is the great challenge of the 21st century [21], and technologies such as cloud computing, IoT, BD, and Blockchain are innovations that are changing people's behavior and business processes in public and private entities. The incorporation of technology has been a constant in business environments since the Industrial Revolution. However, currently, the intensity and speed of introduction of new technologies applied to all areas of life and, especially to the business environment, along with its breadth of application and its main common denominator, its digital component, is leading to a new revolution. Some authors, like Rifkin [6], even suggest that the consequences of the digitalization of the economy and social relations push to a change in the economic paradigm that will condition market relations and, consequently, business activity, strongly conditioned, as Tapscott and Williams [22] pointed out, for massive collaboration, socialization of knowledge, and intensive use of code and open data.

Regardless of the sector, there is no doubt that the digital economy alters the companies' methods of manufacturing and delivering goods and services [7]. Despite this, it seems clear that not all organizations are faced equally with these trends and differences in the use and intensity of digitalization, and this can have an impact on the positioning of companies and become an important factor of differentiation [12]. However, the digital transformation needs strong analytics capability [23], and that implies investing in people, processes, and technology of data and analytics [24].

2.2. Digitalization as Economic and Social Strategy for Cooperatives

In a changing environment like the current one, Social Economy companies should potentiate their strengths and solve their weaknesses, always facing external threats. In this management, it may be important to take advantage of the opportunities offered by ITs, in order to reach better competitive positions [25]. In this sense, Montegut et al. [26] established that cooperatives as companies that operate in the market, should not be left out of this progress, rather they should be at the forefront of this technological revolution if they wish to compete with the other organizations present in each sector.

Moreover, Rodenes and Torralba [16] determined that cooperative values of self-help, self-responsibility, democracy, equality, equity, or solidarity can be facilitated and enhanced with the appropriate Knowledge Management at the service of the cooperative, as a corporate and business organization. In this way, the presence on the Internet in them is considered of great interest, in order to maintain and/or increase its potential, also making it compatible with its own values and principles [27].

In this vein, Vargas [17] established that the implementation of digital technologies marks a point before and after in the operation of the cooperative societies. These will be left behind in competitiveness if they do not make use of those automated solutions, by facilitating appropriate access to information, allowing the optimization of the level of customer service and the degree of reaction to their demands. Moreover, this implementation, according to Castel and Sanz [25] must start from the managers, who must realize the importance of its use to achieve improvements that allow acting efficiently from an economic and social point of view.

In this sense, Meroño and Arcas [28] established that digital technologies can offer very interesting opportunities in relation to the necessary participation of the members in the management of the cooperative, since they are provided with something fundamental for this, such as greater effectiveness in the treatment and transmission of information (objectives, organizational keys, planning, decisions, etc.), eliminating the problem of geographic dispersion that cooperatives sometimes present [25,29]. Thus, Internet provides cooperatives with an important instrument for participation and management of organizational knowledge, making it possible to obtain, process and distribute them where and under the conditions that are necessary, which allows for faster decision-making and a more effective solution of the problems [30], giving rise, in sum, to more flat and decentralized organizations [31].

2.3. New Challenges for the Agricultural Sector: the Smart Agri-Cooperative

The digitalization of the processes in the agricultural sector is transforming it into a smart one, producing more with less, and working with more efficient use of natural resources, more sustainable activity, and also more transparent to the customers [13]. For authors like Rose and Chilvers [32] it is possible to talk about the fourth global agri-tech revolution, Agriculture 4.0.

In addition, this digitalization of activities is transforming the agricultural sector into a more efficient and sustainable economic activity. For example, drones are helping farmers to control and optimize the quantity of nitrogen used to fertilize their crops, or remove pests with precision, using the minimum quantity of pesticides, or robots are used to soil mapping activities improving the quality of the nutrients and expanding the farmers' capacity in order to control and manage large and wide crops [33]. Disruptive technologies, such as, robotization, are changing the agricultural sector transforming it, and are creating new business opportunities, for example, agricultural data-analysis companies, such as Agribotix [34].

This study focuses on the agricultural sector, which has relevant economic and social weight in Spain. According to Cogeca [35], agricultural cooperatives represent an important part of the activity of the agri-food sector with a turnover of 30,992 million euros in 2018 and grouping 3,755 companies and 1,150,241 members throughout the country. In addition, it employs 100,883 workers, mostly in rural areas, which makes these types of companies an authentic economic, social, and cultural engine of rural and less populated areas of Spain. Agri-cooperatives base their activities on the use of endogenous resources and in the most equitable distribution of income [30], contributing to more sustainable development of the area in economic, social, and environmental terms.

Agri-cooperatives can convert traditional business models, conventional agriculture activities, into smart ones. From the different activities of the value chain of the sector, how the different digital technologies can help to agri-cooperatives to adapt their strategy into a more sustainable one will be summarized next. However, not all digital technologies are smart technologies and there is not a consensus about the concept of smart agriculture. This phenomenon is related with the incorporation of digital technologies into the machinery and equipment used in the agriculture process activities, generating a large amount of data [36]. For the purpose of this study, digital technologies are classified into non-smart technologies (web site, electronic commerce, and social networks) and smart technologies (IoT, robots, AI, BD, and Blockchain).

Regarding non-smart technologies and the use of Internet, in general terms, companies are considered to evolve through three phases [27]: Company with web, Internet-enabled company, and company configured and reinvented for the Internet. First, the company uses the web to be positioned on the Internet for advertising purposes or for transmitting information (financial, for agents-partners, suppliers, or customers). Second, the Internet-enabled company uses the capabilities that Internet enables, but without significant changes regarding its position in the value chain of its sector, and electronic commerce begins to be applied to different areas of the company, such as the electronic management of the supply chain. Third, the company configured and reinvented for the Internet is based on the reconfiguration and rethinking of a company's business model to maximize its competitive advantage based on the intensive use of IT. In addition, these companies develop social network profiles as a communication channel with customers [37] or for the promotion of products or services [38], among others.

In short, as Cristóbal et al. [39], although these digital technologies have revealed themselves as an important source of innovation that contributes to the improvement of the competitiveness of the agri-cooperatives, in this sector, there is evidence revealing the difficulties for the implementation of these technologies and their application for effective electronic commerce, all in spite of the fact that these tools offer an important opportunity for the fulfillment of some of its main functions, such as promoting, coordinating, and developing common economic goals of its partners and strengthening and integrating their economic activity. In any case, it should be borne in mind that investing in digital technologies is not enough to be more competitive, but it is necessary to understand the technology, and how to make adequate use of it [18,40]. More specifically, some of the most common problems that cooperatives have suffered in relation to new technologies are the following [17]: lack of integration between the systems, lack of employee preparation, employee resistance, lack of a person responsible for the implementation of the project and the results of the project, problems keeping up to date with new technologies, and lack of cooperation.

This has been corroborated by the work carried out by Bernal et al. [41] on the quality of websites in the agri-food sector, determining that Spanish companies producing organic olive oil have a significant deficit with respect to the quality of their websites, a situation that is still worst case for companies operating with the legal form of cooperative. Therefore, these authors encourage these companies to invest in the quality of their website, an essential tool in the design and implementation of strategies to expand or diversify their business.

Finally, in a study conducted for agri-cooperatives operating in Spain with more than 10 partners/employees [42], the analysis shows that only 55.46 percent of the agri-cooperatives under study have a corporate website, which evidences the existences of some delay in the agri-cooperative sector in terms of Internet-compared presence with the average result achieved by the Spanish business sector. In this sense, Fernández et al. [18], for the olive oil sector, established that the current globalized environment and the widespread increase in the dissemination and use of digital technologies by companies and consumers, make the use of these technologies essential for cooperatives in order to better compete in the market. Likewise, Cristóbal et al. [39] established that the future of cooperativism must be approached with new perspectives focused on innovation and the use of IT, such as the use of the Internet in all its dimensions.

Related with smart technologies, the incorporation of these technologies into machinery and equipment in agriculture exploitations is another step in the industrialization of the sector. Nevertheless, in some regions like Europe, these technologies have been adopted by only 25 percent of the farmers [43]. Next, how the smart technologies (IoT, robots, AI, BD, and Blockchain) can improve the operational efficiency of agri-cooperatives will be summarized [12].

Regarding the IoT, this consists in the digital interconnection of all types of everyday objects using the Internet. This expression was first used in 1995 by Kevin Ashton and refers to the ability of certain networked smart devices to digitalize external data, process, and exchange it over the Internet [36]. For Rifkin [6] this is an extension of the Internet known until now, by allowing the connection of all things with all people in an integrated global network. The IoT is closely linked to another of the key digital technologies, BD. In fact, the IoT generates significant amounts of information that needs to be stored, managed, transferred, analyzed, displayed, and used intelligently and even automatically. In this vein, Akoka et al. [11] listed three characteristics of the IoT that conform to the BD, abundant terminals that generate large amounts of data, data generated by the IoT are usually semi-structured or unstructured, and the IoT data are useful only when analyzed. This reinforces the role of participation in the production of services and the economy of services or innovation among organizations jointly [44]. In olive agri-cooperatives in Europe, the project Internet of Food and Farm 2020 is working in demonstrating that IoT can integrate the whole supply chain from the fields, logistics, processing to the retailer, known as "automated olive chain" [45].

In terms of automatization, other technologies related with processing activities are robots. The use of industrial (for example, for cutting or filling activities) or service robots (for surveillance, cleaning or transportation), can help in the automatization process of some activities of the agri-cooperative [15].

AI refers to machines that have flexible rational capacity, that is, they analyze their environment and carry out actions that maximize their chances of success in the performance of their task [46]. Thus, the machine is capable of mimicking the cognitive functions of humans, such as learning or solving problems [47], or what is the same, making decisions. Together with BD, algorithms allow greater automation of operational and strategic decision-making [48], which have traditionally been considered complex and require human judgment [49] for what seems to be adequate and even necessary, its incorporation and use in organizational management. The new generation of AI is rapidly expanding and has again become an attractive topic for research [50], it has been in existence for over six decades and the rise of super computing power and BD technologies appear to have empowered AI in recent years. According to Paschen [51], from a knowledge management perspective, the fundamental impact that AI will bring about will be on how AI enables the transformation of vast amounts of data into information and ultimately knowledge. However, it has been stated that if organizations aim to realize any substantial performance gains from their AI investments, they must develop and promote an AI capability [52], and AI capability is defined by Mikalef et al. [52] (page 2) as 'the ability of a firm to orchestrate organizational resources and apply computer systems able to engage in human-like throughout processes such as learning, reasoning, and self-correction towards business tasks'. Consequently, in order to be able to deploy such technological innovations and for them to be applied to business tasks, a firm-wide effort is required [52]. In smart agriculture, AI and BD are used, for example, in farm production activities. Furthermore, in combination with autonomous vehicles, such as tractors and drones, these technologies can help, for example, to monitor the growing process of olive trees [34] or AI algorithms that can provide early olive tree disease detection [15].

The BD phenomenon originated thanks to the digitalization processes and the extraordinary expansion of the data flow worldwide, being possible thanks to the development of technologies capable of capturing, processing, and distributing digitally generated information in a decentralized manner [53]. Its volume requires advanced analytical technologies that allow its use to develop knowledge, products, and services and it is defined by volume, speed, and variety. Additionally, the characteristics of truthfulness, visualization, and value are usually added [11]. All of this is conducted in the BD value chain: Data generation, data acquisition, data storage, and data analysis [49,54]. In addition, linked to the BD phenomenon, and due to the volume of data generated, and treated, solutions related to cloud computing become especially relevant for companies [11]. Furthermore, BD analytics capability includes resources and technology, human skills, data-driven culture, and organizational learning [23]. BD provides information and transforms the business, being a competitive force [55].

In sum, data itself is a core resource and it is important for firms to possess an infrastructure capable of storing, sharing, and analyzing data [54]. BD analytics contributes to digitally enabled service innovation, and in this vein, Lehrer et al. [56] found how BD analytics technologies are generative digital technologies that provide a key organizational resource for service innovation. Regarding the business value of BD, Mikalef et al. [57] examined the indirect relationship between a BD analytics capability and two types of innovation capabilities (incremental and radical), and their results confirm the indirect effect that BD data analytics capability has on innovation capabilities, finding that dynamic capabilities fully mediate the effect on both incremental and radical innovation capabilities. Consequently, as these authors found, BD is a necessary resource, but not sufficient condition to result in business value gains. Similarly, Mikalef et al. [58] stated that there is still limited understanding of how firms translate the potential of such technologies into business value and that the literature argues that to leverage BD analytics and realize performance gains, firms must develop strong BD analytics capabilities. Their study shows that BD analytics is more than just mere investment in technology and collection of vast amounts of data. There are important elements of gaining business value out of BD investments. It is the combined effect of resources that will enable a firm to develop a BD analytics capability and realize value gains, which means that a multitude of processes need to be put into action, requiring top management commitment and a clear plan for firm-wide BD analytics adoption and diffusion. Clearly, for cooperatives, this is a key point, as without the support of the partners and top management they will not gain real business value from adopting these technologies.

In this respect, Liu et al. [5] in a research about risk avoidance and coordination of supply chain, established that through another technology, Blockchain, transaction costs among members of the supply chain can be reduced, information sharing can be realized, and the benefits of the supply chain can be improved. In addition, Li et al. [59], in a study on the use of Blockchain technology in the construction sector, found that these technologies have real potential to support digitalization in this industry. Furthermore, they provide solutions to many of its challenges, such as the use of smart contracts to automate payments and other activities, reforming procurement practices and supply chain activities through tracking of goods and services from origin to in situ use, automated equipment leasing using smart contracts, digital twinning (where Blockchain would provide verified data of an asset to a potential buyer or provide real-time data through sensors and smart contracts), automating payments and contracts through the use of smart contracts, and others. Many of them can be extrapolated to the agricultural or other sectors. This technology could impact all the stages of the agricultural chain. Blockchain is a decentralized database, which cannot be altered and is distributed among different participants, while being cryptographically protected and organized into blocks of related transactions between them. The consensus is precisely the key to the Blockchain system, since it is the foundation that allows all participants to rely on the information that is recorded in it [60]. This technology is probably the most disruptive since the advent of the Internet and is able to transform industries by decentralizing trust, generating exchange of goods and services without the need for third parties. For example, it can be very useful for paying transactions, it has the potential to change everything [61], and in the case of agri-cooperatives, this technology can help in certification process [15] or improve the transparency to the customer [62].

The adoption of these smart technologies in the agricultural sector is still reduced, some authors have analyzed some drivers and barriers to this development, for example, Das et al. [63] have found that the younger producers are adopters and the cost of the technology is stopping the smart farming in the case of Ireland. According to Kernecker et al. [64], the unclear value added and the difficulty of coupling the technology with existing systems limit the development of smart agriculture in Europe. In terms of facilitators, Caffaro and Cavallo [65] found, in a research developed in Italy, that the size of the company is related with the adoption of smart technologies and the level of education of the farmers.

3. Agri-Cooperative Digital Strategy: A Digital Diagnosis Tool

According to the previous summarized literature, digitalization is imperative for companies nowadays. In fact, digital technologies have the capacity of transforming sectors completely and every company needs to respond to this challenge [12]. In addition, several authors have pointed out in recent years the positive relationship between the introduction and use of digital technologies and business efficacy and efficiency [42,66]. Companies need to implement technological innovations in order to remain competitive and to create higher added value [7]. Other studies indicate that there is a positive effect of the implementation of digital technologies on the performance of companies in terms of productivity, profitability, market value, and market share [67].

3.1. Digitalization Process: Strategies in Agri-Cooperatives

In this research, based on Parviainen et al. [68], it is proposed that the digital transformation process in agri-cooperatives is incremental and depends on the level of use of digital technologies (y axis) and the level of impact of these technologies in the value chain of the cooperative (farm production-processing activities-packaging-sales, marketing-logistic, and distribution-consumers) (x axis) (Figure 1). However, it is important to point out that a clear digital strategy is a prerequisite to the successful deployment of a large-scale digital transformation initiative, where also the human capital factor is determinant (human capital and management dimension) [69].

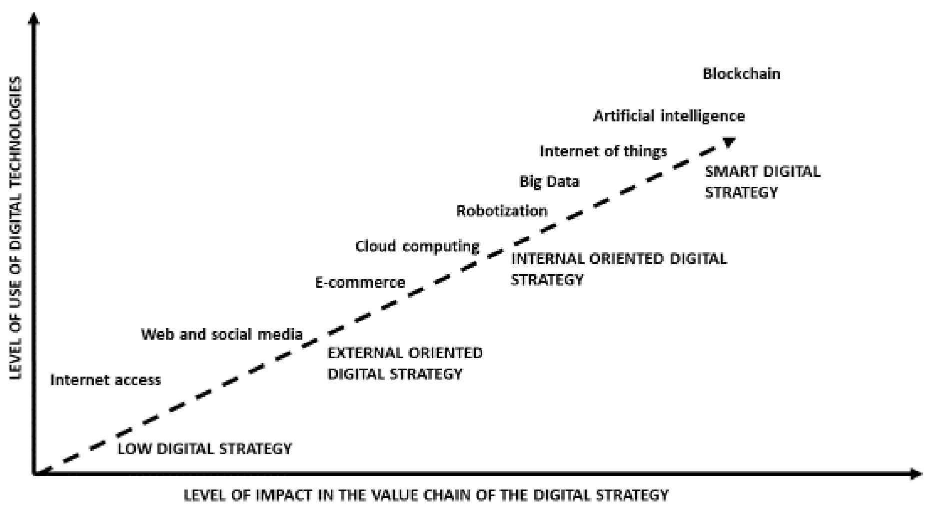

Figure 1. Digital transformation process in agri-cooperatives.

In Stage 1 (Low digital strategy), the agri-cooperative uses the Internet, but this is not considered an asset to offer possibilities to improve business management, find new markets, etc. The cooperative has an Internet connection, a static web page, a social network profile, but without using them as interaction tools. There are not own-human resources involved in the digital transformation.

In Stage 2 (External oriented digital strategy), the agri-cooperative is looking for external opportunities, begins to use the Internet as a basic means of communication and relationship with its stakeholders, originating a bidirectional communication process that is extremely valuable for the company. It begins to automate, although still with manual control, certain areas through information systems (sales, purchases, production) which causes some savings in time and costs and some devices, as tablets, indicate the need to perform digitized tasks. However, the purchase and sale of products or services is still generally carried out through traditional channels. In this case, some human resources are dedicated to the implementation of digital technologies.

In Stage 3 (Internal oriented digital strategy), the agri-cooperative is looking for internal efficiency, begins to carry out economic transactions (buying and selling) with customers and suppliers through the Internet. On the other hand, progress is being made in the integration of its internal information systems, and there is a certain link between internal and external systems. It is possible that the presence of fintech technology for relations with banking and electronic commerce, as well as the use of its own applications (Apps) or participation in other existing ones to have a greater presence in the channels linked to the use of smartphones. Additionally, other technologies are possible, such as web positioning strategy through either specialized personnel or external professionals, digital certificate or electronic signature and electronic invoicing. Furthermore, they are present in the majority of the predisposition variables to change such as, among others, the digitalization plan, an investment budget, a collaborative and open organizational culture, availability of personnel specialized in digitalization and use of IT, or the collaboration of the figure of the community manager.

In Stage 4 (Smart digital strategy), there is an integration of all the operations of the value chain, from the purchase to the after-sales service, and, what is more important, data generated is managed and used. The company is also linked, in terms of collaboration, to external agents (customer-suppliers). There is an organization with real-time responses, which is able to understand and anticipate the needs of its customers, personalizing its products and services, as well as the needs of the cooperative. In addition, all activities and tasks that may be subject to it are automated, and the technology necessary for BD implementation is introduced. The agri-cooperative are involved in projects related with IoT, Blockchain, AI, and the automation of activities (using robots or drones).

3.2. Agri-Cooperatives Digital Diagnosis Tool

Diagnostic tools are widely used in the context of technology adoption, and previous research established that these instruments can help companies to identify problems or new challenges and understand the different dimensions involved in the innovation process [70,71]. It is normal that companies have a lack of knowledge in terms of new technologies and how these technologies are implemented in their own sector. Consequently, according to Brady et al. [70] and Nylén and Holmström [71], academics can develop practical tools in order to help companies to take decisions in new contexts or regarding new technologies.

In this vein, agri-cooperatives need to verify their degree of digitalization and to make decisions in order to increase it, if needed. Taking stock of the previously described situation, and in order to analyze the degree of digital transformation, a digital diagnosis tool named Agri-Cooperative Digital Diagnosis Tool (Agri-CoopDDT) is proposed. This digital diagnosis tool is proposed based on the literature review and the digital technologies used in the activities of the value chain of the agricultural sector. From the identification of these technologies and how they are associated with technologies with a greater or lesser impact on the said value chain, and understanding that their implementation has an impact also at the organizational level (structure, human resources, etc.), the digital diagnosis tool was designed. This is based on questionnaires designed by Eurostat in the context of the European

Statistics for measuring the use of digital technologies in companies [72]. Thus, these measures in cooperatives will result in indicators that are directly comparable with the average of their country at the level of the use of digital technologies and will allow a self-assessment of the situation in which the cooperative is in relation to the context of development of the described digital technologies. Furthermore, its application could result in improvements to these companies' managerial systems. Thus, the Agri-CoopDDT is a tool that allows, through the application of a specific methodology, to estimate the degree of digitalization of the organization (Table 1).

Table 1. Agri-Cooperative Digital Diagnosis Tool.

Human capital and management dimension
The agri-cooperative employs digital technologies specialists Digital technologies specialists are employees for whom digital technologies is the main job) The agri-cooperative provides training to develop digital technologies related skills of the personnel The agri-cooperative recruits or try to recruit digital technologies specialists The agri-cooperative employs specialists to perform digital technologies functions (for example, maintenance of digital technologies infrastructure; security and data protection) 1. Agri-cooperative own employees 2. External suppliers
Access and use of the Internet dimension
1. The agri-cooperative uses a fixed line connection to the Internet (fiber optics technology, cable, etc.) 2. The agri-cooperative provides portable devices to the workforce, which allows a mobile connection to the Internet using mobile telephone networks (portable computers, tablets or smartphones)
Web site and social network dimension
The agri-cooperative uses the web site for: 1. Description of goods or services or price information 2. Online ordering or reservation or booking, for example: shopping cart 3. Possibility for visitors to customize or design online goods or services 4. Tracking or status of orders placed 5. Personalized content on the website for regular/recurrent visitors 6. Links or references to the enterprise's social media profiles The agri-cooperative has the following chat service for customer contacts: 7. A chat service where a person replies to customers 8. A chatbot or virtual agent replying to customers The agri-cooperative uses any of the following social media: 9. Social networks (Facebook, LinkedIn, etc.) 10. Cooperative's blog or microblogs (Twitter, etc.) 11. Multimedia content sharing websites (Instagram, YouTube, etc.) 12. Wiki-based knowledge sharing tools The agri-cooperative uses any of the above mentioned social media to: 13. Develop the enterprise's image or market products 14. Obtain or respond to customer opinions, reviews, questions 15. Involve customers in development or innovation of goods or services 16. Collaborate with business partners (suppliers) or other organizations (public authorities, non-governmental organizations, etc.) 17. Recruit employees 18. Exchange views, opinions or knowledge within the enterprise
Electronic commerce dimension
The agri-cooperative sales goods or services via: 1. Agri-cooperative's websites or apps? (including extranets) 2. E-commerce marketplace websites or apps used by several enterprises for trading goods or services? (*Amazon*, *Alibaba*, etc.)
Cloud computing dimension
The agri-cooperative buys any of the following cloud computing services used over the Internet: 1. Email 2. Office software (word processors, spreadsheets, etc.) 3. Storage of files (as a cloud computing service) 4. Hosting the enterprise's database(s) 5. Finance or accounting software applications 6. Customer Relationship Management (CRM) software application for managing information about customers 7. Computing power to run the software used by the enterprise
BD dimension
The agri-cooperative performs BD analysis on any of the following data sources: (excluding external service providers) 1. Data from smart devices or sensors (Machine to Machine M2M- communications, digital sensors, RFID, etc.) 2. Geolocation data from the use of portable devices (portable devices using mobile telephone networks, wireless connections or GPS) 3. Data generated from social media (social networks, blogs, etc.) The agri-cooperative has another enterprise or organization to perform BD analysis

Table 1. *Cont.*

IoT dimension
The agri-cooperative uses any of the following interconnected devices or systems that can be monitored or remotely controlled via the Internet (IoT): 1. Smart meters, lamps, thermostats to optimize energy consumption in a cooperative (warehouses, production sites, distribution sites) 2. Sensors, RFID or IP tags* or Internet-controlled cameras 3. Movement or maintenance sensors to track the movement of vehicles or products, to offer condition-based maintenance of vehicles 4. Sensors or RFID tags to monitor or automate production processes, to manage logistics, to track the movement of products
Robotization dimension
The agri-cooperative uses any of the following types of robots: 1. Industrial robots (drones, robotic tester, laser cutting, robot filling, etc.) 2. Service robots (used for surveillance, cleaning, transportation, etc.)
Blockchain dimension
The agri-cooperative uses Blockchain systems?
AI dimension
The agri-cooperative uses AI systems?

Source: own work and Eurostat [72].

In order to apply the Agri-CoopDDT tool and tests it, two agricultural cooperatives completed the auto diagnosis with the support of the research team to clarify terms. The manager and a member of the Governing Council were interviewed in order to obtain the information. The identifying data of the two cooperative cooperatives are shown in Table 2.

Table 2. Agri-CoopDDT application to olive oil agri-cooperatives in Andalusia.

	Agri-Cooperative I	*Agri-Cooperative II*
Activity	Table olive and olive oil	Table olive and olive oil
Number of partners	750	200
Foundation year	1967	1997
Interviewee	Manager	Member of the Governing Council
Human-capital and management dimension	Employ digital technologies specialists, provide training, digital technologies managed by external suppliers	Digital technologies managed by external suppliers
Access and use of the Internet dimension	1, 2 (*)	1, 2
Web site and social network dimension	1, 2, 4, 6, 9, 10, 11, 13, 14, 15, 16, 17, 18	1, 2, 4, 6, 9, 14
Electronic commerce dimension	1	1
Cloud computing dimension	1, 2, 3, 4, 5, 6	1, 2, 3, 4, 5
Digital Strategy	Internal oriented	External oriented

(*) See codes in Table 1. Only the ones used by the analyzed cases are included.

According to this analysis, Agri-Cooperative I is developing an internally oriented digital strategy. This company employs digital technologies specialists and provide training to the members of the organization related to IT, also receives advice from external suppliers. The use of the web site and the social networks is high (for recruiting and sharing knowledge), and the management of the information is distributed using the cloud computing systems. This company is looking for external opportunities and internal efficiency, improving the processes, trough digital technologies.

Agri-cooperative II is in a low level of digital transformation, external oriented digital strategy. This company is using cloud computing services, but the level of use of the web and social networks is less intense. In terms of human capital and management dimension, the management of the digital technologies is subcontracted to external suppliers and does not provide training to their members about digital technologies.

4. Conclusions

4.1. Conclusion

The digitalization process based on smart technologies (IoT, robots, AI, BD, and Blockchain) is transforming the agricultural sector and promoting sustainability in different ways. From an economic sustainability perspective, the evolution of smart agriculture can help to improve the efficiency of the exploitations, and open new ways of interaction with customer directly. Furthermore, the development of digital technologies is attracting new jobs or business related with the digitalization. In terms of environmental sustainability, the potential impact of technologies, such as IoT, is relevant in reducing water consumption or pesticides and fighting against climate change. Another relevant perspective are the social issues, agricultural exploitations are located in rural regions, and smart agriculture development can help to attract population (social sustainability). Therefore, the development of smart agriculture is essential for several reasons and public institutions are working on the diffusion of the benefits between different stakeholders [15].

However, the poor infrastructure of Internet in some rural areas, the low technological level of the farmers, and the size of the exploitations are barriers to the development of smart agriculture, and cooperatives have, in this sense, an important role. Additionally, from perspective of olive oil consumer, agri-cooperatives must turn to smart-cooperatives, as now the market is global, not regional. Consequently, cooperatives can play a key role in this context, helping farmers to face challenges together. Maintaining inertia and concentrating on traditional activity can no longer be considered a viable option. It is necessary to diversify the activity, innovate and collaborate with others, incorporating talent and using new technologies in order to better compete in a sustainable way. The first step in this process can be to measure, using the developed digital diagnosis tool, the level of digitalization that the company has, in order to reflect and propose new development and improvement strategies that allow obtaining competitive advantages. In the case of cooperatives, this, together with the social vision and the organizational approach that positions the person at the center of the structure, can relaunch these societies to the place they deserve.

4.2. Contributions

This research provides a revision of the different digital technologies from different perspectives, and an explanation of how they can improve the efficiency of the activities of the agri-cooperatives. Furthermore, it defines different types of digital strategies according to the level of use of the technologies and the impact in the value chain. In addition, the concept of smart agriculture has been adapted to the agri-cooperatives perspective, and the barriers and some facilitators have been discussed, according to the literature. Finally, a digital diagnosis tool for helping agri-cooperatives' digital innovation was designed. This tool has been initially applied to two cases of agri-cooperatives in Spain. As mentioned, digital innovation processes still are unchartered territory for many companies, and they need to have in place appropriate tools for managing digital innovation [71]. Similar to what is proposed by Nylén and Holmström [71], a digital diagnosis tool is defined in this paper, and it should be a welcome contribution, as it is informed by recent research and industry developments and could inspire cooperatives' managers, as well as further scholarly research in this domain of managing digital innovation. Similar to the proposal of Mikalef et al. [52], for AI, from a practical perspective, the proposed instrument can be used to identify areas that have been neglected and formulate a roadmap in order to streamline deployments and increase business value in the digital innovation involving the analyzed technologies. As a framework informed by recent research exploring the unique properties of digital innovation in agri-cooperatives, it contributes to a better understanding of digitalization of agri-cooperatives in the context of smart agriculture.

4.3. Implications

Cooperative partners and managers of agri-cooperatives can use this tool to analyze the stage of digitalization process that the organization has already reached and promote their development. At policy level, this Agri-CoopDDT can help the institutions of a specific region to know the level of the digitalization of the existing agri-cooperatives, and, consequently, to have better designed political instruments in the context of promoting a more sustainable environment.

4.4. Limitations

This paper provides an exploratory approximation to the phenomenon, and more data are needed to advance in the definition of the proposed digital diagnosis tool.

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