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Innovation in farming: Drivers of adoption of Precision Agriculture amongst farmers

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ABSTRACT

The recent changes in technological innovations in agriculture in the last decades are radically changing the paradigm of traditional cultivation techniques and these have already been the subject of research for some time. The present study aims to review the new trends of digital technologies adoption in precision agriculture. Starting from theoretical study models such as the Agriculture Knowledge and Innovation Systems (AKIS), the Agricultural Innovation System (AIS) and the new modeling of the Farm Management Information System (FMIS), a review was carried out with the aim of identifying emerging adoption drivers for the implementation of precision agriculture technologies. To do this, 19 papers were analyzed in the period 2018-2021 that included empirical investigations. The results of the survey confirm the new adoption trends where, in addition to the size of the agricultural company, the geographical position and the financial resources, sociodemographic factors are included and above all the new emerging trend linked to environmental benefits.

Keywords: *Precision Agriculture; Innovation Drivers; Adoption Drivers; Innovation; Agri-Food Management.*

1 Introduction

Recent changes in the world of technology, brought about by innovation processes, remain a key driver in socio-economic transformation over the centuries and improvements in human well-being (FAO, 2022). These processes of innovation and change affect all sectors of the economy and agriculture is no exception. Innovations in agriculture have been undertaken thanks to various elements such as the centrality of the supply chains that lead to horizontal relationships between different players and an increase in investment, necessary to broaden knowledge. Over the years, several scholars have highlighted how innovation in its forms, especially that of Open Innovation, remains a topic of great strategic importance for the agri-food sector (Lacoste et al., 2022; Long and Blok, 2018; Meynard et al., 2017; Misra et al., 2022).

Chesbrough (2006) defines "Open Innovation" as "the use of intentional inflows and outflows of knowledge to accelerate internal innovation and respectively expand markets for external use of information". Open innovation becomes, therefore, a new paradigm that defines internal and external ideas to companies, as well as internal and external paths to the market and helps companies to guarantee their technological progress. Another crux of the theory is the network that companies are able to create is their ability to build a network with public or private institutions, with universities or their spin-offs, that can give a constant flow of information to the company. This model adheres perfectly to a world increasingly dominated by the tertiary sector and by the advanced tertiary (or quaternary) sector. Several studies on agriculture have highlighted how some determinants are of fundamental importance in terms of Open Innovation (Dong et al., 2013; Long and Blok, 2018). Dong et al., (2013), found that the adoption of the Open Innovation paradigm was highly successful in stimulating agricultural policies in the Chinese county of Sanjiang both helping the central government in building the policy and for farmers by noting greater yield per hectare of crops and at the same time a balance of the agricultural ecosystem. According to the Long and Blok research (2018), carried out by European entrepreneurs who develop innovation for agriculture with a view to environmental sustainability, there is a great possibility of making "exploratory activities of open innovation" and "dimension of responsible ones" coexist by defining this new model of Open Innovation 2.0. Meynard et al (2022) point to the importance of greater integration in the design processes of the agri-food system to improve their sustainability achievable by activating not only technological but also organizational innovation processes.

In fact, within the agricultural system, various theoretical approaches have included the analysis of innovation in the sector itself. Starting from these general considerations on the innovation process in the agri-food sector, various theoretical approaches have been developed to guide the analysis. The research on the Farming System starts from the relationship between the world of agriculture and the scientific one. The latter defines the agricultural system as a meeting point and sees all the members of the agricultural family and all the processes involved (Dedieu et al., 2009) as an approach. The Agriculture Knowledge and Innovation Systems (AKIS) approach, on the other hand, extends the boundaries of analysis. This approach is used to describe the mutual learning between actors in the supply chain and organizations. Nowadays it assumes that the encounter between these two worlds generates knowledge as far as agriculture is concerned. This knowledge is used to share information with the aim of working synergistically to support decision making, problem solving and innovation in agriculture in a particular country or domain (EIP-AGRI, 2018; Röling, 1990).

Another theoretical approach is, instead, the Agricultural Innovation System (AIS) defined by a World Bank report (2006) as "a network of organizations, businesses and individuals focused on the introduction of new products, new processes and new forms of organization in economic use, together with the institutions and policies that influence their behavior and performance". The need to create interactions between the actors of the whole value chain is central in this approach as it underlines how important it is to exchange information even with those who seem to be "outside the farm gate" (Klerkx, 2015). In this theoretical model, as shown in Figure 1, the position of the policy and of the institutions, that can be either a potential support or an obstacle for the innovation processes (Aerni et al., 2015), may have a strong effect on the main actors of the agricultural supply chain. In fact, the model proposes an interaction between all the actors (from research centers to final consumers) and institutions in order to create partnerships and links along the agricultural value chain with the aim of encouraging its development.

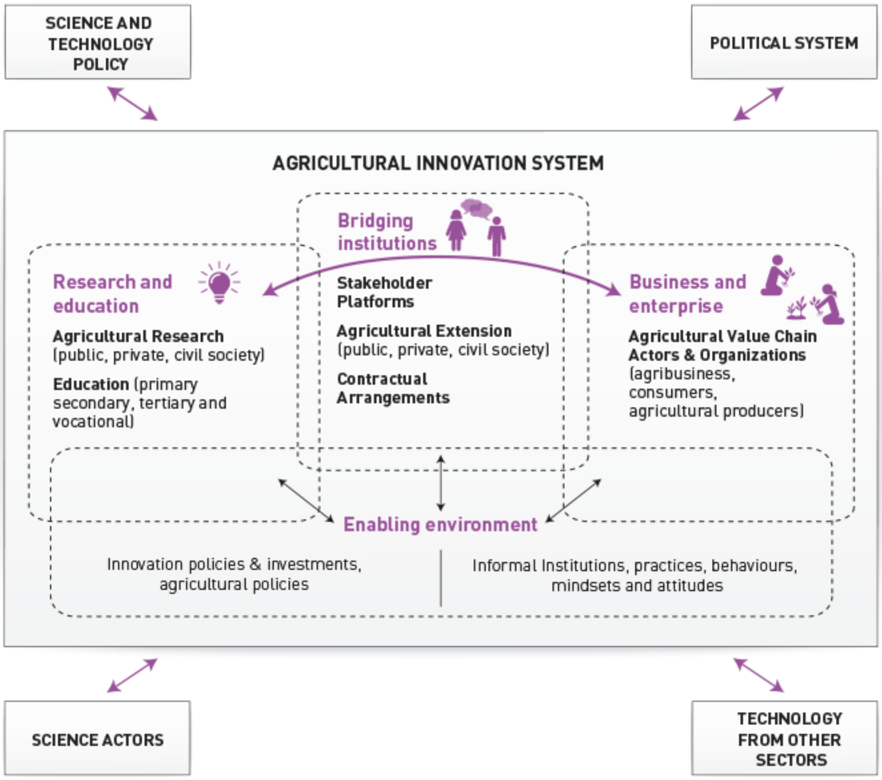

Figure 1. Agricultural Innovation System (Source: Food and Agriculture Organization (FAO), adaption from Aerni et al., 2015).

2 Farm Management

The history of agricultural management has been filled with contributions and revisions since the beginning of the last century. Butterfield's first study on Farm Management dates to 1910, the factors of production within the farm, economy and maintenance of the integrity of the soil are highlighted in it. Among all the definitions given in Table 1 it is possible to see how they all focus on the decision-making process regarding the allocation of resources. These definitions are, today, out of date mainly for two reasons: 1) the world of agriculture is constantly evolving; 2) they refer to a farming world with a family orientation which, although still existing, is no longer as it used to be at least from the definitions given by Butterfield (1910) to Dillon (1980). Castle (1987) refers to the question of profitability while Kay and Edwards in 1994 describe Farm Management as a decision-making process. Ultimately, according to Kaloxylos et al., (2012)'s approach, Farm Management is interfacing with all the modern challenges of agriculture, from global trade to traceability and to the needs of a sustainable supply chain.

The role of economic theory within management has been debated at length by various researchers and, in the middle of the last century, the centrality of studies and research was the economics of production and mathematical programming, leaving little room for the study of factors critical to successful agricultural management (Gray et al., 2009; Jensen, 1977; Malcolm, 1990). Harsh criticism was made during that period, defining the studies as a progressive departure from real agricultural practice (Giles and Renborg, 1990). Several authors have concluded that, while central to agricultural management studies, economics alone is not sufficient to provide a complete picture (Giles and Renborg, 1990; Harling and Quail, 1990; Johnson, 1957). Within business management theories, Farm Management can be best expressed as the integrated consideration of two complementary theoretical frameworks derived from modern management theory: the theory of the agricultural system and the theory of management by objectives (Kast and Rosenzweig, 1974). While the former sees the farm as a targeted system, providing a checklist of the aspects of the business that should be of concern for management, the latter also encompasses planning, organization and control strategies using economic principles and administrative procedures. On the other hand, analyzing the farm's ability to innovate, it is correlated with performance, so innovation is a facilitator within management processes (Crossan and Apaydin, 2010).

Table 1.
Farm Management definition over a century.
(Source: elaboration on FAO, 1997 (http://www.fao.org/3/w7365e/w7365e0f.htm)).

Authors	Definition
Butterfield, 1910	"[Farm management is concerned with] how can the individual farmer so organise the factors of production - land, labour and capital - on his farm, so adapt practice to his particular environment, and so dispose of his product, as to yield him the largest net return, while still maintaining the integrity of his land and equipment"
Heady and Jensen, 1954	"Farm management, as the subdivision of economics which considers the allocation of limited resources within the individual farm, is a science of choice and decision making"
Dexter and Barber, 1960	"Farm management is concerned with the organisation and deployment of the resources put into a farm business - the land, the capital, the labour and that item of over-riding importance, the ability and skills of the individual farmer"
Barnard and Nix, 1973	"[Farm management] is concerned with the organization of resources, with planning their use, both within and between enterprises, and with the control of plans both during their implementation and afterwards"
Dillon, 1980	"[Farm management as] the process by which resources and situations are manipulated over time by the manager of the farm system in trying, with less than full information, to achieve his or her goals"
Castle et al., 1987	"Farm management is concerned with the decisions which affect the profitability of the farm business"
Kay and Edwards, 1994	"Farm management can be thought of as being a decision-making process. It is a continual process ... The decisions are concerned with allocating the limited resources of land, labor, and capital among alternative and competing uses. This allocation process forces the manager to identify goals to guide and direct the decision making"
Kaloxylos et al., 2012	"Farm management deals with the organization and operation of a farm with the objective of making a livelihood whilst dealing with global trade, traceability and consumer requirements, agricultural policies, environmental requirements, and the multi-functionality of agricultural enterprise as a whole."

Farm Management Information System

According to Salami and Ahmadi (2010), the Farm Management Information System (FMIS) can be defined as a system that deals with collecting, processing, storing and disseminating data, translating it into information necessary for carrying out the operational functions of the farm. In fact, the FMIS systems have been integrated over the years with innovative agricultural technologies to help the farmer improve strategic planning and optimize the work done in the fields (Kaloxylos et al., 2012; Nikkilä, 2010) evolving from company-wide registrations to complex management support systems (Fountas et al., 2015). In a 2007 study, Murakami et al. proposed a design model dedicated to an FMIS highlighting the most important determinants, as shown in the Figure 2.

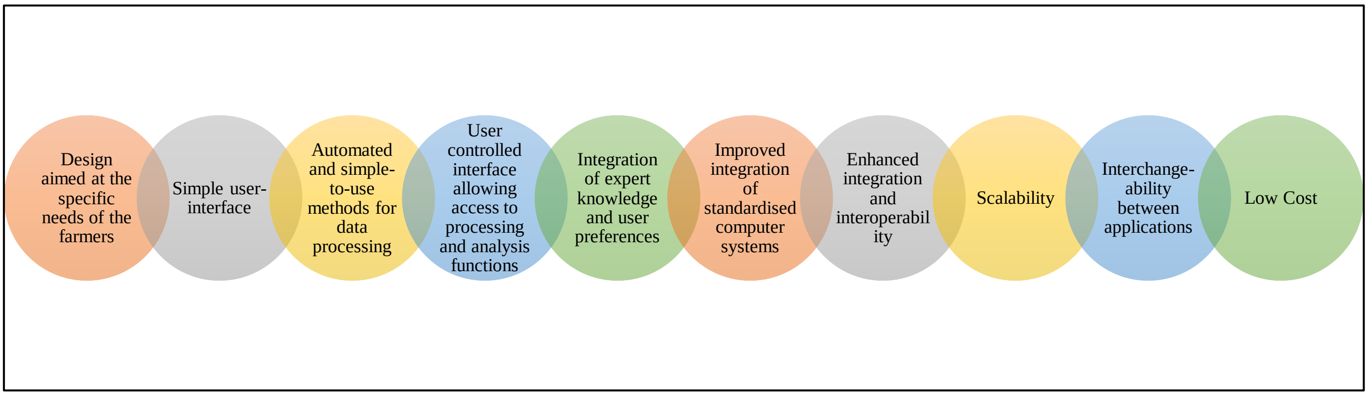

Figure 2. Requirements for a Farm Management Information System.
(Source: elaboration on Murakami et al., 2007)

As also highlighted in Sørensen et al. (2010)'s studies, it is necessary to establish the essential boundaries of the FMIS; these boundaries are identified in the form of actors, i.e. software, and functionality. The characteristics presented by the FMIS used daily and commercially available are those intended for software suited for specific types of agriculture or for livestock farming (Nikkilä, 2010). Studies were also carried out with the aim to identify the integration of FMIS with modern precision agriculture techniques such as the integration of the ISO 11783-2:2017 defined ISOBUS where the use of precision agriculture technology integrates with the FMIS to store detailed information on all tools available for field operations on the farm (Fountas et al., 2015; Nikkilä, 2010). The evolution of needs for farms therefore seems to highlight the need for increasingly sophisticated information and communication systems that can adapt to Precision Agriculture technologies. In this sense, the evolution of FMIS systems takes into account not only the technological component but also the human nature of business processes, especially where the social aspects are a key factor (Fountas et al., 2015).

3 Agri Food Innovation Driver

As highlighted in the previous paragraph, the success of an innovation lies in the ability to combine sources of external and internal knowledge and in the surrounding network, and the agri-food sector is therefore not an exception. The drivers of influence in the innovation process appear to be different and of a different nature for companies operating in the agri-food sector. First of all, it is necessary to distinguish between internal innovation drivers and external ones as they both play a fundamental role in the innovation process. Following the approach of Capitanio et al., (2009) revised by Tarabella et al., (2019) these factors can be represented. Among the drivers of internal innovation, it is possible to mention Size, Legal Status, Age, Financial Capacity, Human Capital.

Their size is related to the dimension of the organization, which can be more or less complex. In the case of large companies, there is usually a strong market power and a conservative character, while small and medium-sized companies show a high degree of flexibility and a high potential for incentives as far as innovation is concerned. Several studies in literature have highlighted how the “Size” of the land in terms of hectares is a factor that can influence the trend towards innovation (Cavallo et al., 2014; Daberkow and McBride, 2003; Pierpaoli et al., 2013; Tey and Brindal, 2012).

The “Legal Status” concerns investor-owned companies and cooperatives. Both of the above mentioned are linked to a hierarchical structure where decisions are taken from the chief executive while cooperatives base their structure on common cultures and partnership opportunities. As for the “Age”, mature companies have a strong know-how and a structured hierarchy but also less propensity towards any kind of innovation, if compared to start-ups; the latter are more dynamic but with limited financial resources. “Financial Capacity” is largely based on the relationship between the ownership and the management. Finally, “Human Capital” where the experience of the involved subjects, the level of training and the mission and value of the company, play central roles.

Table 2.
Drivers of adoption of Precision Agriculture (Source: Elaboration on Pierpaoli et al., 2013).

Ex-Ante	Competitive and contingent factors	Trialability / Observability
		Size
		Facilitating factors
		Perceived ease of use
	Socio-demographic factors	Social Factors
		Age
		Previous experience
		Education
		Confidence
		Perceived ease of use
	Financial resources	Cost
		Perceived benefit
		Perceived usefulness
Ex-Post	Competitive and contingent factors	Geography
		Size
		Soil quality
	Socio-demographic factors	Age
		Computer confidence
		Information
		Education
	Financial resources	Income
		Ownership and tenure
		Full time farmer

Then there are types of drivers external to the company. In this case, the most important factors are the market dynamics combined with the company's export strategies. The "Geographical Location" and the "Relationships with the Institutions" are other important factors to be considered among the possible drivers of innovation. The model proposed by Pierpaoli et al., (2013), reported in Table 2, is much more specific and focused on Farmer's drivers of new Precision Agriculture technologies adoption. Pierpaoli et al., (2013) divided the determinants of Precision Agriculture technologies adoption into Competitive and contingent factors, socio-demographic factors, financial resources both for Ex-Ante and Ex-Post approach.

In the Ex-Ante approach, i.e. in an attempt to identify the decision to adopt a new technology before it occurs, the main factor of influence is "Financial Resources" represented in this case by the cost of the technology and the benefits and usefulness perceived in the case of adoption. For the "Socio-demographic factors", the presence of experts on the territory appears to be a good stimulus towards adoption. The "Perceived Ease of Use", on the other hand, appears to be influenced by various socio-demographic factors and by the familiarity that potential adopters have with new technologies. Basically, as widely stated in previous theories, the "Size" of the company turns out to be largely relevant to the competitive and contingent factors.

The Ex-Post approach, focuses on the farmer who has already adopted innovation as a farmer with a medium-high education, with a large company and quality soil geographically well positioned. Also, in this case, the "Socio-demographic" variables appear to be central although the value of the variable "Age" is much discussed; in some cases it seems, in fact, that young people are more oriented towards new technologies, in others it is the exact opposite, with older farmers being more willing to accept them. For what concerns the "Financial Resources", other studies focused on European farmers reveal how in Europe farmers are less tied to financial benefits and how, having companies in Europe on average smaller than their American counterparts, the owners of small companies often create a net of cooperation between companies of the same size.

4 Materials and Methods

Following the Hart (1998) and Pierpaoli et al. approach (2013), research on the Scopus database was carried out. By using the keywords "Precision AND agriculture AND Adoption" and "Precision AND farming AND Adoption" with the years of selection from 2018 to 2021 a significant increase in research on the topic was detected, compared to the historical trend of research on the topic, as reported in the Figure 3. The first search of the database generated around 300 results.

Subsequently, an initial screening was carried out following the selection criteria for the contributions which concerned exclusively "Articles, Conference Papers and Reviews", the contributions were written in English, eliminating duplicate results. At this point, a further screening was carried out exclusively on the articles based on empirical studies centered on the adoption of precision agriculture technologies, excluding works focused on environmental, policy or energy issues to avoid including articles excessively focused on one or more drivers.

Finally, 19 papers were selected and used for the analysis, at the time of the conclusion of the research, no references for the year 2021 were considered valid for inclusion in the analysis while 3 papers were included for the year 2018, 6 for the year 2019 and 10 for the year 2020 (see table 3).

5 Innovation Drivers

5.1 Size

Size is one of the structural variables of a farm, in a broad sense the quality of the soil can also be considered as part of this category. The size of the farm appears to be one of the most cited aspects among the drivers of new technologies adoption, as already theorized by several studies (Daberkow and McBride, 2003; Pierpaoli et al., 2013; Tey and Brindal; 2012) and confirmed in this analysis (Barnes et al., 2019a; Barnes et al., 2019b; Gallardo et al., 2019; Gardezi and Bronson, 2020; Groher et al., 2020a; Khanal et al., 2019; Kolady et al. , 2020; Konrad et al., 2019; Michels et al., 2020a; Michels et al., 2020b; Ofori et al., 2020; Quintana-Ashwell et al., 2020; Tamirat et al., 2018). However, subject to discussion in the literature is the definition of a "large" farm. Although a large farm has been identified as having a total arable area greater than 500 hectares in some American studies (Batte and Arnholt, 2003) this measure is not applicable to the European context. For the sake of completeness of information, it is recalled that the average size of a farm in the USA is 170 hectares compared to an average of 14.2 hectares in Europe and "only" an average of 7.9 hectares in Italy (Eurostat, 2013). In this regard, it is worth noting that in their study Groher et al., (2020a) analyzed what were considered to be large farms in Switzerland, holdings exceeding 30 hectares of land. In any case, the literature confirms that a larger farm is more inclined to plan investments in new technologies and that large commercial farms are more likely to benefit economically from the adoption of the PA (Gardezi and Bronson, 2020).

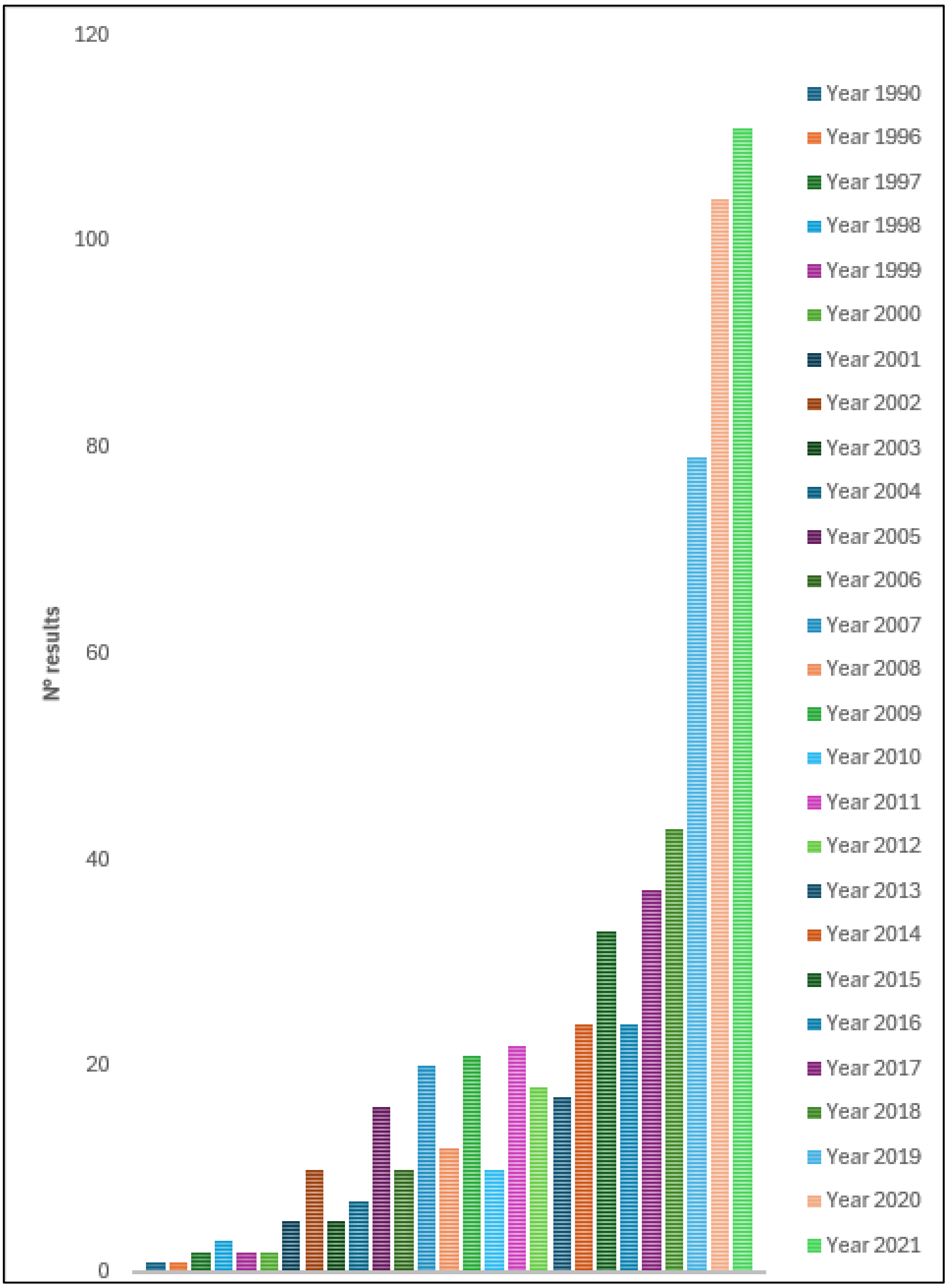

Figure 3. Number of contribution results on the Scopus database. Source: elaboration by the authors.

Table 3.
Adoption Driver of Precision Agriculture technologies.

Authors	Method	Data source	Sample	Driver Emerged
Ayerdi Gotor et al., 2020	Qualitative	Questionnaires	23 French farmers practicing PA	Socio-demographic factors
Barnes et al., 2019a	Count data modelling framework	Face-to-face interview	971 European farmers	Socio-demographic factors, size
Barnes et al., 2019b	Random Intercept Logistic Regression	Face-to-face interview	971 European farmers	Size, Financial Resources
Dhanai et al., 2018	Binary logistic regression method	Questionnaires and Face-to-face interview	122 Indian farmers	Socio-demographic factors, Financial Resources
Gallardo et al., 2019	Probit model	Electronic mailing lists	119 US apple farmers	Size, Geography
Gardezi and Bronson, 2020	Multilevel logistic regression	Mail and secondary data	Almost 5 000 US corn and soybean farmers	Environmental benefits, Socio-demographic factors, size
Groher et al., 2020a	Binary logistic regression	Postal questionnaires	2657 Swiss farmers	Geography, Size
Groher et al., 2020b	Binary logistic regression	Postal questionnaires	1497 Swiss farmers	Geography, Socio-demographic factors
Khanal et al., 2019	Bayesian methods	Postal questionnaires	545 US cotton farmers practicing PA	Financial Resources, Size, Socio-demographic factors
Kolady et al., 2020	Probit model	Postal questionnaires	198 US farm-operator respondents	Size, Financial Resources
Konrad et al., 2019	Probit model	CAWI, postal questionnaires and email	2439 European farmers	Size, Socio-demographic factors, Geography
Michels et al., 2020a	Ordinal logit regression	Online questionnaires	167 German farmers	Size, Socio-demographic factors
Michels et al., 2020b	Bivariate probit model	CATI[1] and CAWI[2]	815 German farmers	Size, geography, Socio-demographic factors
Ofori et al., 2020	Cox proportional-hazard (CPH) model	Panel data	316 US farmers	Size, geography, Socio-demographic factors, Financial Resources
Paudel et al., 2020	Monte Carlo simulations	Postal questionnaires	1692 US cotton farmers	Financial Resources, Environmental benefits
Pokhrel et al., 2018	Multivariate fractional regression model	Postal questionnaires	1812 US cotton farmers	Socio-demographic factors, Geography
Quintana-Ashwell et al., 2020	Probit model	Telephone-based survey	148 US row-crop farmer	Size, Socio-demographic factors, environmental benefits
Tamirat et al., 2018	Binary logit regression	Cross section survey	260 European farmers	Size, Socio-demographic factors, Geography
Vecchio et al., 2020	Logit	Questionnaires	174 Italian farmers	Socio-demographic factors

[1] Computer-assisted telephone interviewing (CATI) is a telephone surveying technique in which the interviewer follows a script provided by a software application.
[2] Computer-assisted web interviewing (CAWI) is an Internet surveying technique in which the interviewee follows a script provided on a website.

5.2 Socio-Demographic Factors

The social and demographic constructs of this section appear to be specific to the farmer. Historically, studies in the literature tend to focus on distinct socio-demographic variables such as age and education in relation to adoption (Daberkow and McBride 2003; Tey and Brindal, 2012). The most discussed topic in literature (Tey and Brindal, 2012) is, without a doubt, the subject's age. In some cases, it is the younger age that is considered relevant as far as new technologies adoption is considered due to young people's greater familiarity with technological innovations and their wider working horizons (Konrad et al., 2019; Michels et al., 2020a; Michels et al., 2020b; Tamirat et al., 2018). Other studies, however, have shown that old farmers are more willing to use PA technologies (Torbett et al., 2007). For the level of education there is evidence that a higher level of education increases the willingness to adopt new technologies (Dhanai et al., 2018; Vecchio et al., 2020) as cultivated people are more sensitive to some central issues in agriculture such as environmental sustainability (Pokhrel et al., 2018; Tamirat et al., 2018).

5.3 Financial Resources

This category includes all the drivers which express the managerial attitude of the farmer. In this sense it can be said that farmers' choices define the future of their business but that internal and external knowledge of the market and of the company is central in the decision-making phase. New technologies are therefore perceived as risky investments for one's activities, so the choice depends not only on risk attitude but also on income and available financial instruments (Daberkow and McBride, 1998). In this sense, the farm income seems to be central for the adoption of new technologies, the adoption of innovation increases with an increase in income (Dhanai et al., 2018; Paudel et al., 2020), as well as being an economic barrier for non-adopters (Barnes et al., 2019b). Kolady et al., (2020) suggest that producers with off-farm income are less likely to adopt information-intensive technologies than those without. Furthermore, Barnes et al. (2019b), suggest that the use of different financial instruments such as subsidies and different forms of taxation for PA technology adopters may be a positive driver for adoption.

5.4 Geography

Geography represents the link between the farmer and the surrounding environment, both in terms of geographic location and networking. This reveals that the presence of a network (trade associations) is essential when considering the adoption of new technologies, as it can foster targeted economic policies by governments. Opinions, also in this case, turn out to be conflicting. Although the geographic location of the American states is not particularly impactful (Gallardo et al., 2019), the adoption of some water techniques may vary depending on the composition of the soil (Pokhrel et al., 2018). However, strong differences in adoption arise between European states (Konrad et al., 2019; Tamirat et al., 2018). Michels et al., (2020b), in a study focusing on German farmers, suggest that geographic differences within the country exist but are linked to mobile internet adoption in the geographic area of reference. The relationships between neighbors do not appear to be of particular impact in the adoption of new technologies (Konrad et al., 2019). As for the morphological composition of the territory Groher et al., (2020a) state that farms located in mountainous areas have a lower propensity to adopt PA technologies than valley farms.

5.5 Environmental Benefits

Several studies have analyzed how the decision-making process for the adoption of a new agricultural technology may depend on the farmer's perception of the Environmental Benefits such as sustainability and changes in natural systems (Gardezi and Bronson, 2020). Nyaupane et al. (2012) place environmental sustainability among the three major drivers of adoption of new technologies by agricultural entrepreneurs together with profitability and productivity. In their study, Gardezi and Bronson (2020), found out that farmers were more likely to adopt new agricultural technologies when considering changes in natural systems (such as droughts and floods) than when dealing with issues related to environmental sustainability (concern for climate change). Paudel et al. (2020) theorize instead that farmers who have already experienced improvements from an environmental point of view have 15% more probability of adopting new PA technologies for sustainability reasons whereas Quintana-Ashwell et al. (2020) note that participation in the Conservation Reserve Program (CRP)[3] is relevant for the adoption of new PA technologies with a view to sustainability.

[3] CRP is a land conservation program administered by FSA. In exchange for a yearly rental payment, farmers enrolled in the program agree to remove environmentally sensitive land from agricultural production and plant species that will improve environmental health and quality. Contracts for land enrolled in CRP are 10-15 years in length. The long-term goal of the program is to re-establish valuable land cover to help improve water quality, prevent soil erosion, and reduce loss of wildlife habitat (United States Department of Agriculture, 2020).

6 Discussion

This research aims to frame the technological changes that are occurring in terms of adoption by farmers, identifying the potential drivers of innovation. Studies on the adoption of technologies in agriculture have their roots as early as the middle of the last century. The evolution of a sector that for centuries had remained almost unchanged has attracted the attention of many scholars in the sector, as well as control actors and government bodies. Although recent developments in the sector are rapidly changing some agricultural techniques, and with them some needs both on the part of farmers and markets, it must be highlighted how many theories are still valid today, especially in a global market where borders and barriers of geographical areas seem to have fallen. In fact, many of the emerging and developing countries are facing challenges similar to those faced in the past by the so-called “first world” countries. The latter countries, on the other hand, are starting to adopt new agricultural models where the figure of the classic farmer will have to gradually get closer and closer to that of a real manager. For the specific designs of the new management systems of modern farms, which by integrating precision agriculture technologies and conveying information inside and outside the company itself, three complementary approaches have been identified, AKIS, AIS and FMIS. These systems focus on what is the daily management of the farm and in a medium-long term vision, including the management of information and relations with stakeholders inside and outside the supply chain.

In the years covered by the research, following a significant increase in references in the literature which coincides with a trend of greater adoption of new technologies in agriculture (Lowenberg-DeBoer and Erickson, 2019), the theoretical approaches have met with great adherence to the new trends adopted by farmers of all the world.

The techniques analysis and the models prepared for the study of the intentions of adopting new technologies have undergone various developments, precisely to photograph the changes taking place. Technological advances that have been typical of a global transition not only in the agricultural field, which inevitably can and must adapt to improve the models adopted up to now, in the name both of economy but also and above all of global nutrition and environmental sustainability.

7 Conclusion

The drivers of innovation revealed by the analysis on the agricultural sector appear to be varied. On one hand, a global trend towards the overcoming of the parcelling out of agricultural land, with farms becoming, albeit slowly, increasingly larger in number of cultivated hectares without increasing the total number of cultivated hectares. On the other, a greater predisposition to innovation by the new generations of farmers who are more accustomed to the use of technology and on average more educated.

In fact, attention is drawn to how some adoption factors remain unchanged since the first sector studies (Capitanio et al., 2009; Hart, 1998; Pierpaoli et al., 2013; Tey and Brindal, 2012) among which we can note the size of the agricultural company although subjected to the constraint of relativism in the order of the average size depending on the geographical location of the company itself. Sociodemographic factors also appear to have a strong impact on farmers' adoption choices, which are strongly interconnected with other adoption factors such as interest in environmental sustainability. Financial resources can be a vehicle for adoption as well as a barrier to entry while there is a growing interest in environmental benefits which seem to be increasingly perceived as a factor of interest in the adoption of new technologies.

However, some limitations connected to this research must be highlighted, first of all the different methods of adoption and the difficulty in some countries of adequate technological transfer could have caused a loss of information relating to some factors hindering the adoption itself. Furthermore, the geographical issue could be explored more given that most of the research taken into consideration refers to investigations conducted in Europe and the United States of America.

The research aims at being a starting point for any future work to trace new trajectories both in the analysis of agricultural management and to understand the new inclinations of farmers in adopting technologies. In this way, the agricultural sector will be able to count on further elements of development for new management models, thereby increasing the sustainability and resilience of the agri-food chain.

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