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The degree of digitalization and willingness to using digital technologies by the Albanian farmers: An exploratory and econometrics analysis

Ilir Tomorri*, Remzi Keco, Myslym Osmani, Arben Kambo and Shpresim Domi

Faculty of Economy and Agribusiness, Agricultural University of Tirana, Tirana, Albania
**Corresponding author:* itomorri@ubt.edu.al

Abstract

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Agriculture is an important economic sector in Albania, both in terms of its contribution to GDP, and employment. In this sector operate more than 300 thousand farms, most of which are micro and small farms up to 2 ha. Digitalization is thought of as an important means to help agriculture face multiple challenges, such as increasing productivity and efficiency of resource use, competitiveness, food quality and safety, climate change, quality of living in rural areas, ageing, depopulation and biodiversity, all contributing to or being in close relationship with the sustainable development of the agriculture sector and the national economy as a whole. The purpose of this paper is to provide an averall degree of digitalization in the agricultural sector mainly at farm level, and of the willingness of farmers to use digital technologies in their farms. The identification of factors influencing both the actual use of digital technologies and the farmers' willingness of using them in the future is the other facet of the research purpose. To carry out the research we used collected information from 5 regions of the country (Korçë, Kukës, Berat, Fier, Gjirokastër), using face to face interviews for 938 farmers from these areas. To analyse data we applied exploratory statistical tools and econometric regression. Analysis showed that among factors supposed to influence the degree of actual digitalization the most important resulted farmers' knowledge and skills about digital technologies, utility of these technologies as percepted by farmers, availability of technologies, farmers' belief in farming as a benefitial activity, education level and farm size, while age has a negative effect. At the end, some recommendations to improve the level of use and farmer's willingness to use digital technologies in the future are presented.

Keywords: agriculture; digitalization; digital technologies; smart farming; regression model; exploratory analysis

Introduction

Agriculture in Albania occupies an important place in the national economy, with about 20% contribution to the national GDP. The agricultural sector is characterized by micro and small farms. There exist about 300 thousand, 86% of which are micro and small farms of size up to 2 hectares, with an average size of about 1.2 ha exist. The agricultural sector employs the vast majority of the population and about 37% of the country's employed population (MARD, 2022). Sustainable economic growth in Albania is strongly associated with the performance of the agricultural sector (Domi and Arapi, 2021).

The development of this sector is accompanied by problems and challenges such as increasing the productivity of agricultural farms, the small size and high fragmentation of agricultural farms, efficiency of resource use, cooperation between small farmers, access to financing, modernization of the value chain, food quality and safety, marketing and sale of agricultural products, as well as building administrative capacities to support these processes (Tomorri et al., 2024). The topic of this research is digitalization, more precisely digitalization of the agriculture sector of Albania. Digitalization is generally perceived as a positive process, and that also includes some challenges that must be addressed by internal and external actors of the agri-food sector (Kukk et al., 2022). Among these challenges as we will show in the following section, are sustainable agricultural and economic development, and improving the quality of life in rural areas.

Digitalization experience of agriculture in other countries has shown important effects. According to the literature, the effects of digitalization can be classified into three groups: economic (e.g. cost reduction, diversification of production, creation of economies of scale, increase in quality, etc.), social (e.g. facilitation of cooperation and coordination, access to the market, better access to training and acquiring knowledge, increasing transparency and facilitating monitoring, simplifying operations, improving business models, creating new opportunities for business) and environmental such as increasing resource efficiency, biodiversity, use of secondary resources such as recycling, better management of operations along the value chain, etc. (Stoyancheva and Doncheva, 2023).

Other countries, the EU in particular, have given digitalization high priority in the agricultural sector. The EU digital agenda was one of the pillars of the Europe 2020 strategy, with the aim of improving the use of ICT to promote innovation, economic growth and progress. The Digital Agenda was one of the seven pillars of the Europe 2020 growth strategy. The Digital Agenda proposes better use of ICT to foster innovation, economic growth and progress. One of the key priorities of the Digital Agenda is the Digital Single Market (FAO, 2020).

In Albania, according to MARD (2022), the agriculture sector i characterized by a very weak digitalisation and rare investments in precision agriculture. According to (GWP, 2022), precision agriculture and digitalisation in agriculture are still rarely applied and mainly in fruitculture and vegetable production.

Research about digitalisation and its application in the agricultural sector of Albania is very limited if not inexisting at all. Tomorri et al. (2024) have attempted to assess the level of application of specific or groups of digital technologies, such as mobile phones, drones, satellites, etc., measured as percentages of responses along a likert scale from 1 to 5, but did not provide a general measure of digitalization, nor the factors, barriers or drivers of digitalization.

Research problem

Based on the lack of information and knowledge about application of digital technologies, our research problem is the knowledge gap on the level of digitalization in the agricultural sector in Albania, and of important factors or drivers that influence the application of digital technologies in agricultural farms in the context of Albania, as well as the increase in the willingness of Albanian farmers to use digital technologies in the future.

Goal

Based on the research problem, the goal of our study is:

- Provide an aggregate measure of the degree of application of digital technologies by Albanian farmers, at the country level and according to the regions selected in the study;
- Identification of factors and obstacles/barriers, that affect the digitalization of the agricultural sector at farm level in our country;
- Identification of important factors or drivers that influence the increase in the willingness of farmers to use more digital technologies in the future;
- Based on the identifications made, the formulation of recommendations, measures or actions so that farmers, or the farm sector, can use more digital technologies in the future.

Literature review

About the concept of digitalization

Digital agriculture represents new knowledge or new combinations of existing knowledge transformed into technologies applied to agriculture activities and, as a result, aims to improve the sector's performance.

According to Clerck (2017), digitalization is "the use of digital technologies and of data in order to create revenue, improve business, replace/transform business processes and create an environment for digital business, whereby digital information is at the core". According to Reis et al. (2020), digitalization is the phenomenon of transforming analogue data into digital language (i.e. digitalization), which, in turn, can improve business relationships between customer and companies, bringing added value to the whole economy and society.

Referring to other sources digitalization is the process of application of digital innovations. Several digital technologies are cloud, big data, artificial intelligence, Internet of Things (IoT) various micro and nanoelectronics and robotics (Stoyancheva and Doncheva, 2023). Digital technologies can be divided into three groups: basic (phone calls, sms, emails, etc.), medium (online actions such as social media and e-commerce) and advanced (big data analytics, blockchain technologies, IoT, cloud computing, AI) (Nogales and Casari, 2023). Digital agriculture concept includes broad changes along the entire agricultural value chain. Technologies such as smartphones, apps, global positioning systems (GPSs), Internet of things (IoT), sensors, drones, unmanned autonomous vehicles (UAVs), precision agriculture, smart farming are part of digital agriculture (Salemink et al., 2017; Wolfert et al., 2017; Shepherd et al., 2020).

Digital agriculture represents new knowledge or new combinations of existing knowledge transformed into technologies applied to agriculture activities and, as a result, it contributes to improving the sector's performance. According to Rijswick et al. (2019), "digitalisation is often used to describe the socio technical processes surrounding the use of digital technologies, that impact on social and institutional context, that require and increasingly rely on digital technologies.

According to Reis et al. (2018), digital transformation includes three important elements: 1 – Technological use of new digital technologies such as social media, mobile, or embedded devices; 2 – Organizational a change in organizational process; 3 – Social a phenomenon that is influencing all aspects of human life. Artificial intelligence, as one of the most prominent digital tools, in the context of digitalization, is expected to revolutionize the field of agriculture in the future, when robots will perform basic work and services in the field, such as fertilizing, removing weeds, harvesting, etc. (Benfica et al., 2023).

In addition to digitalisation, there exists also the concept of digitization. Digitalization and digitization are not the same. According to Brennen and Kreiss (2016), digitization is the material process of converting analogue streams of information in digital bits. Digitization is the first necessary step of the digitalization process. However, sometimes, the term digitization is used instead of digitalization. We argue that the appropriate term to use is digitalization, being used also by important international organizations as (World Bank, FAO, etc).

About the effects of digitalization in agriculture

Literature points out many reasons why digitalization in the agricultural sector, at the farm level in particular but not only, is very important. Literature argues largely the role of digitalization in catalyzing development and growth, reducing poverty, inequality and facing hunger (FAO, 2020; ITU and FAO, 2020; Nogales and Casari, 2023; Benfica et al., 2023; Piot-Lepetit, 2023). It has socio-economic impact, thus palys a role in protecting biodiversity and environement (OECD, 2022; Basso and Antle, 2020; Lajoie-O'Malley et al., 2020; Piot-Lepetit, 2023; Martens and Zscheischler, 2022).

Enhancing fair market competitiveness as well as competition along value chains (Kitole et al., 2024; Blakeney, 2022; Čehić et al., 2022), it improves famers' access to markets (FAO, 2018; Tomorri et al., 2024; Sylvester et al., 2021; Abbasi et al., 2022). Market access and fair competition is also supported by digitalization through increasing farm productivity (Trendov et al., 2019; Sylvester et al., 2021; Abbasi et al., 2022; El Bilali and Allahyari, 2018; Martens and Zscheischler, 2022; WB, 2016), farm resource and services efficiency (FAO, 2018; Tomorri et al., 2024; Nogales and Casari, 2023; El Bilali and Allahyari, 2018; Martens and Zscheischler, 2022; Finger, 2023; Fielke et al., 2020; WB, 2016), product quality improvement, reduction of production and transaction costs (Nogales and Casari, 2023; El Bilali and Allahyari, 2018; WB, 2016), enhancing economies of scales (Stoyancheva and Doncheva, 2023; WB, 2016), improving collection, processing, and exchange of data and information among actors, buyers and sellers including consumers, reducing the cost of and increases the access to information (Nogales and Casari, 2023; Smidt and Jokonya, 2022; Tomorri et al., 2024; Birner at.al., 2021; Khanna, 2021; Blakeney, 2022; Ehlers et al., 2021; MSU-Manage, 2021; WB, 2016). Through reduced transactin costs the integration of smallholders in value chains is also enhanced (Monda et al., 2023; WB, 2016).

By increasing productivity, resource use efficeiency, product quality, farm products competitiveness and market access digitalization helps in improving income and more general the economic performance of farms (**Šermukšnyte** and Melnikiene, 2024; Zhang and Fan, 2023). Through higher productivity and production, it helps in feeding a growing population (Piot-Lepetit, 2023).

Digitalisation supports sustainable development (OECD, 2022; Piot-Lepetit, 2023; Mhlanga and Ndhlovu, 2023; Trendov et al., 2019; Nogales and Casari, 2023; Prasetyo and Setyadharma, 2022; Sridhar et al., 2023; Ferrari et al., 2022). Competitiveness and fair competition is supported also by the role of digitalisatin in increasing farm economies of scale (Stoyancheva and Doncheva, 2023; WB, 2016), enhancing cooperation and coordination along value chains (Ehlers et al., 2021), improving transparency and monitoring, food products and inputs traceability, cooperation and coorination along the value chain (OECD, 2022; Trendov et al., 2019; Nogales and Casari, 2023; Smidt and Jokonya, 2022; Ayre et al., 2019; Finger 2023; Passarelli et al., 2023. WB, 2016), improving communication between actors along the value chain and consumers (Trendov et al., 2019; Van ES and Woodard, 2017; Nogales and Casari, 2023; Smidt and Jokonya, 2022).

Improving the access and cost of data enables farms and companies, even small ones and farms to reach more distant markets and reduce transaction costs Nogales and Casari, 2023 ; Tomorri et al., 2024). Digitalization helps in improving acces to and the quality of extension services and farmers access to them (FAO 2018; Spielman et al., 2021; Blakeney, 2022; WB, 2016). Digitalization can promote circular economy (Gil-Lamata et al., 2024).

Digitalization helps in easing problems related with aging or emigration (Nogales and Casari, 2023; Blakeney, 2022) and in reducing problems with lack of farm labor force (OECD, 2022).

One of most important effects of digitalizatiion is promoting innovation, supporting and improving access to innovative agricultural technologies by farmers (OECD-Eurostat, 2018; FAO, 2020; ITU and FAO, 2020; WB, 2016). It can enhances climate resilience by facilitating using climate smart technologies for the adaptation to climate change and mitigation of its effects (Trendov et al., 2019; OECD, 2022; Piot-Lepetit, 2023).

As literature points out, digitalization can ease access of farmers to finance and bank loans, improve safety of payments and money transactions (Sylvester et al., 2021; Abbasi et al., 2022; WB, 2016). In relation to farm operatins, digitalization makes possible automatation, unmanned farm operations, remote monitoring and control of farm, but not only operations (Verdouw et al., 2021). It improves the operation of business (farms), by improving business models and practices (Trendov et al., 2019; Van ES and Woodard, 2017; Stoyancheva and Doncheva, 2023; Sylvester et al., 2021; Rolandi et al., 2021; WB, 2016), supports optimizing production and food systems, as well as value chains management, adding value to agriculture and value chain (Tomorri et al., 2024; Klerkx et al., 2019; WB, 2016), including technical optimization of agricultural production systems, value chains and chain coordination (Mathidle et al., 2022; El Bilali and Allahyari, 2018).

Using digital technologies digitalization entrepreneurship development (Prasetyo and Setyadharma, 2022; Sridhar et al., 2023). It also can support disadvantaged groups and their social inclusion (Nogales and Casari, 2023).

About factors influencing the degree of digitalization in agriculture

The literature has also identified many factors that affect the degree, extent or speed of digitalization in agriculture. According to (Mhlanga and Ndhlovu, 2023) some limiting factors are: resource scarcity, limited expertise and training, a lack of digital infrastructure, data privacy and security concerns, and resistance by farmers.

Albanian literature highlights important obstacles to agricultural development and, consequently, to the spread and adoption of innovations and new technologies, such as: limited access to quality inputs and adequate financial services for smallholder farmers, uncertainties surrounding land ownership, limited market access for agricultural products, insufficient adoption of modern technologies, a lack of collaboration among farmers, the small size of the farms, insufficient extension services as well as poor access to information provision. This not only leads to the lack of implementation of new technologies but also to the reduction of productivity and competitiveness (Tomorri et al., 2024).

Regarding barriers to innovations (including digital ones), the literature (Smidt and Jokonya, 2022) distinguishes four types: economic, political, social and institutional. Economic factors include access to capital and financial services, as well as the model or strategy applied in agricultural production. In this aspect, the authors suggest the implementation of the precision agriculture model. Market access and competitiveness are two other important factors of this group. Among the political factors are: promoting agricultural innovation, supporting rural capacity building, and the provision of pro-poor innovations. The third group includes factors such as: sustainable production, this also in the social and environmental sense, and the improvement of the information and communication techmologies (ICT) opportunities, as far as possible, including the involvement of young people and women. In the fourth group, an inclusive development framework is included, which helps the adoption of digital technology by farms, especially small ones. In this aspect, the most important are the building of institutions and creation of rules to support farmers in adopting and using digital technologies.

According to Kieti et al. (2022), the obstacles for digital technology are of three types: technology accessibility (technology infrastructure and digital skills); service discoverability; service value proposition (service usability and service affordability). Public policy is an important factor and is included in this triple grouping. According to (Nogales and Casari, 2023), the obstacles of SMEs, including small farms to the use of digital technologies, are the size, business ambitions and those for their development, lack or high cost of digital infrastructures; low awareness of digital technologies; limitations in local digital solutions; lack or limited of digital and literacy; lack of financial support; lack or ineffective advisory service; inadequate rules related to digital technologies.

According to the OECD, major determinants of adoption include farmers' age, human capital, perceptions of technology, and quality-of-life gains and farm scale. Major constraints to adoption continue to be technology costs, user-friendliness, relevance, clearly demonstrated net benefits, lack of hig high-speed internet connectivity, and mistrust in tools sometimes perceived as "black box" technologies (OECD, 2022). Other literature argues that basic conditions are the minimum conditions required to use technology and include: availability, connectivity, affordability, ICT in education and supportive policies and programs (e-government) for digital strategies; enabling conditions ('enablers') are factors that further facilitate the adoption of technologies: use of internet, mobile phones and social media, digital skills and support for agripreneurial and innovation culture (talent development, sprint programs including hackathons, incubators and accelerator programs (Trendov et al., 2019).

Education is very important as a driver of digital technology use. Education as well as income levels are strong determinants of how (and if) people use the internet. Those with higher levels of education tend to use more advanced services, such as e-commerce and online financial and governmental services. Users with lower education levels tend to use the internet predominantly for communication and entertainment. In rural areas, where education and literacy rates are generally lower, mobile phones and social media tend to be used mainly for communication. This presents a challenge for the introduction of digital agriculture applications, which require more advanced digital skills. A well-developed digital infrastructure, and access to the internet especially in rural areas, is a precondition for digital agriculture and food (Trendov et al., 2019).

Some important obstacles to agricultural development and, consequently, to the spread and adoption of innovations and new technologies, are: limited access to quality inputs and adequate financial services for smallholder farmers, uncertainties surrounding land ownership, limited market access for agricultural products, insufficient adoption of modern technologies, a lack of collaboration among farmers, the small size of the farms, insufficient extension services as well as poor access to information provision. This not only leads to the lack of implementation of new technologies, but also to the reduction of productivity and competitiveness (Tomorri et al., 2024).

As far as Albania is concerned, studies identifies several problems: low spread of the fixed broadband network, huge rural-urban gap of fixed lines, insufficient digital skills of the active population, lack of digital records of agricultural land (lack of a land parcels identification system-LPIS, farm accounting data network-FADN registers) etc. (FAO, 2020). ITU identified the lack of rural connectivity as "one of the major gaps" that hampers growth in the country (Mulliri et al., 2022). According to the literature, in 2019, 69 percent of the Albanian population aged 16 to 74 was using the Internet; and more than half of the households (57 percent) had broadband Internet access. However, fixed broadband penetration remains at very low levels compared with other countries in the region and within the EU. Furthermore, there is a huge gap of fixed-line penetration between urban and rural areas. Broadbrand penetration in rural Albania is 5% of fixed lines; only 10% of total subscriptions are in rural areas (GoA, 2020). According to the World Economic Forum Executive Opinion Survey, the level of digital skills among the active population is 4.67 on a scale of 7 (FAO, 2020).

In the last ten years, Albania has made progress in terms of developing digital infrastructure. In order to prioritize digitalization, the Albanian government has drawn up several strategic documents. Through these documents and strategies, it was intended to encourage the use of information technologies and the development of information technology infrastructure as the key to its successful implementation. E-Albania is the online government platform, where public services, previously provided at the physical offices, are now provided electronically to the society (citizens, businesses, and NGOs). The platform offers several services to the stakeholders along the agriculture value chain, mostly related to the grant schemes. The e-service "Application for the National Support Scheme for Farmers" involves securing financial support for agriculture and rural development, provided by the Albanian government.

In the framework of digitalization, the Agriculture and Rural Development Agency opened the network of "Agro Points" or "Farmer's Windows" (AGROPIKA). This provides farmers with information for applications, access to finance, extension support and other services. In total, 20 Agro Points have been opened, reaching each territorial branch throughout the country (FAO, 2020). The Regional Agency of Agricultural Extension (RAAE) also supports applicants for grants and subsidies schemes by using the e-Albania platform. This agency plays an important role in supporting farmers to upload the required documents to their e-Albania account, as well as facilitating the process of knowledge transfer in terms of using digital technologies in farm activities. Actually, Albania has a plan for sustainable development of digital infrastructure. One of the objectives of this plan is sustainable development of broadband infrastructure and reducing digital divide. Two of specific objectives are: 1) by the end of 2025, 100% of households in rural and remote areas to have 100% of broadband access with at least 100 Mbps. 2) 100% of schools to be connected with high speed-broadband internet with 1 Mbps (GoA, 2020).

Albanian literature points out that major barriers impeding digitalization are small size of the farm, limited financial resources, low level of familiarity with technology and the lack of digital infrastructure in rural areas, but also affordability, for both fixed and mobile broadband access (Mulliri et al., 2022).

Research hypotheses

H_1: The size of the farm, the education of the farmer, gender (more men), increased knowledge, utility, working only on the farm, the belief that agriculture is an activity that brings benefits, availability technologies when needed, influence positively the degree of implementation of technologies; the size of the farming family, the number of working family members, age and lack of capital affect negatively the degree of implementation of technologies.

H_2: The size of the farms, the education of the farmer, the gender (more men), the increase in knowledge, the usefulness, the degree of actual use of technologies, employment only on the farm, the belief that agriculture is an activity that brings benefits have a positive effect on the willingness to implement of technologies; the size of the farming family, the number of working family members, age and lack of capital negatively affect the farmer's willingness to implement technologies.

Data and Method

Data

In order to achieve the purpose and objectives of the study, a questionnaire was designed to collect information from the farmers (interviewed). The questionnaire is composed of five main sections, to provide information on:

- farmers and agricultural farms, (family members, gender, age, education, employment and income);
- data on productive resources (land, owned/leased, activities, capacity, investments);
- digital technology data (devices, applications, platforms, etc.);
- data on income and expenses;
- data on socio-economic factors.

Based on the data of INSTAT (2023), for the dominant activities and the typology of farms, questionnaires were completed face to face with farmers for the regions selected in the study. In total, 938 questionnaires were filled out. The data were obtained through a survey with direct sampling. The completed questionnaires according to the respective districts are: Gjirokaster (200 questionnaires, 21.3%), Berat (199 questionnaires, 21.2%), Fier (189 questionnaires, 20.1%), Korçë (183 questionnaires, 19.5%) and Kukës (167 questionnaires, 17.8%).

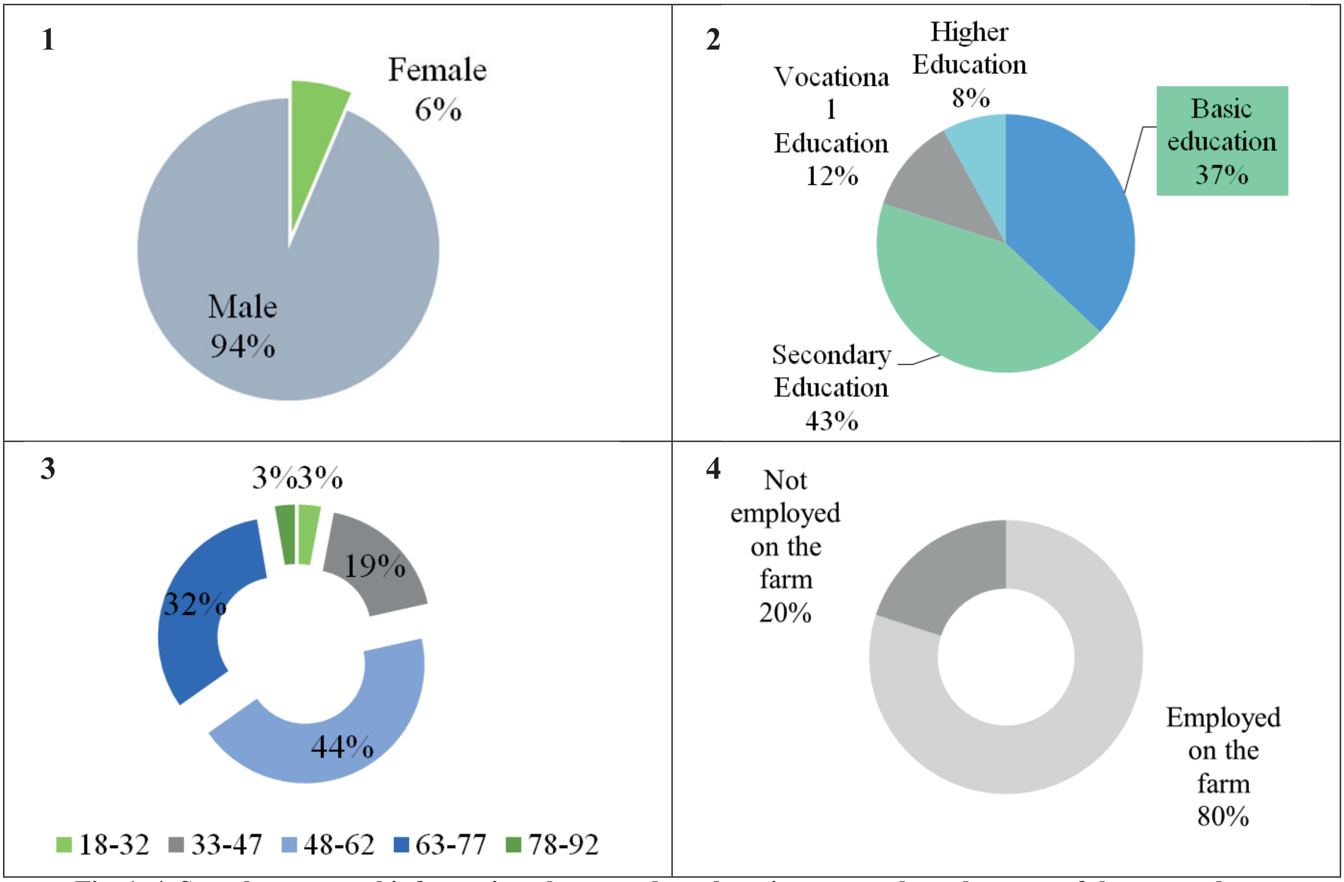

Fig. 1–4. Sample structural information about gender, education, age and employment of the respondents
Source: Authors' results, 2024

In accordance with the purpose and objectives of the study, to analyze the data collected, we used descriptive and exploratory statistics (means, medians, percentiles, cross-tabulation, graphs, etc.), regression models (econometric modeling) and logit binomial regression. The variables we used are as shown in Table 1 below.

Method

To analyze the data collected, we used descriptive and exploratory statistics (means, medians, percentiles, cross-tabulation, graphs, etc.), one-factor regression (econometric modeling) and logit binomial regression. Use of a triple research method is based on the fact that a large number of

Table 1. Variables, their measurement scale and operationalization

Variable	Code	Measurement scale	Operationalization
Gender	GEN	Dummy	0=Female, 1=Male
Age	AGE	Ratio	Years
Education	EDU	Nominal	1=Primary, 2=General Secondary, 3=Professional Secondary, 4=University
Number of Household Members	MEMBER	Ratio	Members
Number of working in farm	WORKMEM	Ratio	Members
Working only in farm	EMPLO	Dummy	0=No, 1=Yes
Total owned land	TOTOWNL	Ratio	Dynym
Agricultural production is not profitable	NOPROFIT	Dummy	0=Other, 1=Yes
We have no capital or other resources (labour, machinery, etc.) for tilling the land	NOCAP	Dummy	0=Other, 1=Yes
We use applications/platform, mobile/smartphone for various information	APPLIC	Nominal	0=Never, 1=Little, 2=Sometimes, 3=Frequently, 4=Very frequently
We use technology with remote sensors (land, air, water)	SENSOR	Nominal	0=Never, 1=Little, 2=Sometimes, 3=Frequently, 4=Very frequently
We use technologies that apply satellite images	SATELIT	Nominal	0=Never, 1=Little, 2=Sometimes, 3=Frequently, 4=Very frequently
We use UAV technology (e.g., drones)	DRONE	Nominal	0=Never, 1=Little, 2=Sometimes, 3=Frequently, 4=Very frequently
We use technology for data analysis (big data)	BIGDATA	Nominal	0=Never, 1=Little, 2=Sometimes, 3=Frequently, 4=Very frequently
We use technology to make payments through smartphone applications	SMARTPH	Nominal	0=Never, 1=Little, 2=Sometimes, 3=Frequently, 4=Very frequently
Average use of digital technologies	DIGITECNOUSE	Ratio	
I use different videos from the Internet to get the information, that I need	VIDEO	Nominal	0=Never, 1=Little, 2=Sometimes, 3=Frequently, 4=Very frequently
I use text and sms via phone to be informed about different issues	TEXTSMS	Nominal	0=Never, 1=Little, 2=Sometimes, 3=Frequently, 4=Very frequently
I have knowledge on the use of google drive, drop box, etc.	GOOGDR	Nominal	0=Never, 1=Little, 2=Sometimes, 3=Frequently, 4=Very frequently
I have knowledge on using office and similar programs	OFFICE	Nominal	0=Never, 1=Little, 2=Sometimes, 3=Frequently, 4=Very frequently
I provide information through the media (TV, etc.)	MEDIA	Nominal	0=Never, 1=Little, 2=Sometimes, 3=Frequently, 4=Very frequently
Average Digital Knowledge	DIGIKNOWL	Ratio	
The use of technology would improve the performance in doing my jobs	Util1	Nominal	0=Absolutely against, 1=Against, 2=Agree, 3=Absolutely agree
The use of technology in my work would improve productivity	Util2	Nominal	0=Absolutely against, 1=Against, 2=Agree, 3=Absolutely agree
The use of technology would increase efficiency in my work	Util3	Nominal	0=Absolutely against, 1=Against, 2=Agree, 3=Absolutely agree

Table 1. Continued

Variable	Code	Measure-ment scale	Operationalization
I would find the technology most suitable for my work	Util4	Nominal	0=Absolutely against, 1=Against, 2=Agree, 3=Absolutely agree
Average Percepted Utility	UTILITY	Ratio	
I intend to use technology regularly in my work	IntentionUse1	Nominal	0=Absolutely against, 1=Against, 2=Agree, 3=Absolutely agree
I want to use technology for my work	IntentionUse2	Nominal	0=Absolutely against, 1=Against, 2=Agree, 3=Absolutely agree
It is likely that I will use technology in my work in the future	IntentionUse3	Nominal	0=Absolutely against, 1=Against, 2=Agree, 3=Absolutely agree
Average of intention to use digital technologies	DIGITWILL	Ratio	
I want to use technology for my work	IntentionUse-2Dum	Dummy	0=Against and absolutely against, 1= Agree, and absolutely agree
Technology is available when I need it	AVAILABLE	Nominal	0=Never, 1=Little, 2=Sometimes, 3=Frequently, 4=Very frequently

Source: Authors' results, 2024

observations for almost all variables are missing. The effect of missing observations becomes more serious in multifactor linear regression, because results obtained through the estimation could be unrealistic (in terms of value, sign and confidence of model parameters). Based on the nature of the dependent variable, continuous or binomial (dummy) we used classical and logit binomial econometric models. The standard form of the classical linear regression model is:

$$Y = a_0 + a_i X_i + e$$

In this model, Y is the dependent variable; X is the factor or independent variable; a_0 is the free constant of the model, while $\boldsymbol{a}$ is the regression coefficient. The parameter a_0 gives the expected value of Y when X takes the value 0. The parameter $\boldsymbol{a}$ shows how much it changes (increases or decreases depending on the sign), when X increases by one unit. The model is estimated with the OLS method. An important indicator of the model is the coefficient of determination R^2, which takes values from 0 to 100, and shows how much of the variation of Y is brought about by the change of the independent variable included in the model.

The standard form of the binomial regression model is as follows:

$$P_i = P(Y = 1, X_i) = \frac{1}{1 + e^{-a-bX}}$$

or

$$\frac{P_1}{P_0} = \frac{P_1}{1 - P_1} = \exp(a + bX)$$

where Y is a dummy dependent variable with possible values 0 and 1. P_i are probabilities that Y takes the value 1 for given values of the variables X_i. *Exp(b)* is called the odds or relative chance (the probability of making the choice 1 of the dependent variable compared to the probability of making the choice 0) and shows how much the relative chances of an individual making the choice 1 compared to the choice 0 increase or decrease when the variable X increases by one unit. See, Gujarati (2003), Wooldridge (2009), Osmani (2017) and Osmani et al. (2021), for more theoretical details. We used Microsoft Office (Excel) and GRETL software.

Results

Descriptive and exploratory data analysis

Table 2 below denotes the old age of Albanian farmers (57.09 years). Half of them are over 59 years old, and only 5% are under 36 years, while 95% are up to 74 years old. The average use of digital tools is 0.62 and for the half of the farmers it is below 0.33 on a scale of 0 to 4. Digital knowledge is at an average level of 1.348, while half of them have it below 1.2. However, the willingness or desire to use more knowledge and digital technologies is at the average level of 1.9, much more than their actual use.

Below we focus on four important indicators that are supposed to be related to digital technologies (Knowledge and skills, Use, Usefulness and Willingnes to use digital technologies), and analyze the differences between farmers according to region, gender, age, education, farm size, etc.

Table 2. Summary statistics, using the observations 1 – 938

Variable	Mean	Median	Minimum	Maximum
Member	4.2595	4.0000	1.0000	10.000
Age	57.090	59.000	18.000	92.000
Totownl	16.369	14.000	0.80000	154.00
Digitecnouse	0.62324	0.33333	0.00000	4.0000
Utility	2.0271	2.0000	0.00000	3.0000
Digiknowl	1.3481	1.2000	0.00000	4.0000
Digitwill	1.9056	2.0000	0.00000	3.0000
Available	2.4884	3.0000	0.00000	4.0000
Variable	Std. Dev.	C.V.	Skewness	Ex. kurtosis
Member	1.4945	0.35086	0.67655	1.1726
Age	11.855	0.20766	-0.36027	-0.034449
Totownl	14.535	0.88798	5.0390	39.630
Digitecnouse	0.88912	1.4266	1.7979	2.4029
Utility	0.62262	0.30715	-1.2027	2.6650
Digiknowl	0.95946	0.71172	0.42598	-0.54298
Digitwill	0.66539	0.34918	-1.3247	2.2585
Available	0.93371	0.37523	-0.78613	0.78239
Variable	*5% Perc.*	*95% Perc.*	*IQ range*	*Missing obs.*
Member	2.0000	7.0000	2.0000	13
Age	36.000	74.800	16.000	15
Totownl	3.3700	35.300	11.300	265
Digitecnouse	0.00000	3.0000	0.83333	12
Utility	0.50000	3.0000	0.25000	142
Digiknowl	0.00000	3.0000	1.4000	19
Digitwill	0.00000	3.0000	0.00000	195
Available	0.00000	4.0000	1.0000	78

Source: Authors' results, 2024

Table 3 below shows that between rural areas there is quite a large difference (gap) regarding the use of digital technologies, from 0.07 in Kukës to 1.43 in Korçë. This is also the case in the level of relevant knowledge, while the differences in willingness to use more digital technologies are reduced. Positive is the fact that in most of the farmers agree that digital technologies are useful; here too they are close to the average level on a scale of 0 to 4.

As shown in Table 4 below, in all indicators there are differences between the sexes, although not very pronounced. The table shows that age is an important factor for all indicators, where it seems that, in general, older farmers have less knowledge, use less and their willingness to use is lower. However, between young and old farmers there are big differences both in knowledge and in the scale of implementation, in the perceived usefulness and in the willingness to implement.

According to the table, education has to do with the level of knowledge and the application of technologies, as well as the willingness to implement them. Likewise, the indicators

Table 3. Knowledge, use, utility and willingness to use digital technologies (averages) by region

Region	DIGITECNOUSE	UTILITY	DIGIKNOWL	DIGITWILL
Berat	0.49	2.09	1.19	1.96
Fier	0.64	1.63	1.21	1.55
Gjirokastër	0.50	2.24	1.55	2.03
Korçë	1.43	2.18	1.65	2.06
Kukës	0.07	1.99	1.15	1.93
Total	0.62	2.03	1.35	1.91

Source: Authors' results, 2024

have an increasing tendency: with the increase in the size of the farm as the amount of land owned by the farms. Access to capital seems to be another factor that affects the level of indicators. Farmers, who express a lack of capital, have indicators generally at a lower level of use and willingness than those who say the opposite. Those who think that agriculture is not profitable, use digital technologies somewhat less, but not to a very different degree. The most important factor seems to be the availability of digital technologies. Those who are fully employed in their farm seem to use these technologies less than the others (working in other sectors or engaged in other activities).

Table 5 below provides information on the level of indicators according to the question "I want to use technology for my work". Those who respond positively or say they are ready to use technology in their work (1), have all three indicators much higher than the category that is against or absolutely against (0).

Econometric modeling

For this model we have used data for 6 types of digital technologies: Applications/platform based on mobile/smartphone for various information (APPLIC), technology with Remote Sensors (land, air, water) (SENSOR), technology

Table 4. Knowledge, use, utility and willingness to use digital technologies (averages) by some of the variables

VARIABLE	DIGIKNOWL	DIGITECNOUSE	UTILITY	DIGITWILL
GENDER				
Female	1.26	0.60	1.82	1.76
Male	1.36	0.62	2.04	1.92
AGE (Years)				
18–32	2.15	0.86	2.36	2.30
33–47	1.54	0.66	2.20	2.11
48–62	1.42	0.64	2.08	1.93
63–77	1.13	0.50	1.88	1.76
78–92	0.53	0.49	0.92	1.00
TOTOWNL (Dyn)				
0.8–10.8	1.06	0.43	1.95	1.87
10.8–20.8	1.41	0.79	1.96	1.88
> 20.8	1.41	0.73	2.06	1.90
NOCAP				
0 = Other	1.30	0.66	2.00	1.97
1 = Yes	1.08	0.56	1.94	1.69
NOPROFIT				
0 = Profitable	1.22	0.64	1.17	1.28
1 = Non profitable	1.37	0.63	1.78	1.68
EMPLOYMENT				
0 = Not employed in farm	1.68	1.01	2.08	1.98
1 = Employed in fam	1.19	0.41	2.01	1.87
EDUCATION				
1 = Primary	0.89	0.41	1.79	1.61
2 = General Secondary	1.49	0.69	2.15	2.04
3 = Professional Secondary	1.64	0.59	2.17	2.04
4 = University	2.08	0.84	2.40	2.26
AVAILABLE	–		–	–
0 = Never		0.24		
1 = Little		0.36		
2 = Sometimes		0.44		
3 = Frequently		0.59		
4 = Very frequently		1.42		
TOTAL	1.35	0.62	2.03	1.91

Source: Authors' results, 2024

that apply satellite images (SATELLITE), UAV technology such as drones, (DRONE), big data analysis technology (BIGDATA), technology for payments through smart phone applications (SMARTPH). All these variables are measured with the scale 0 = Never, 1 = Little, 2 = Sometimes, 3 = Frequently, 4 = Very frequently. As a dependent variable, we use their arithmetic mean (a continuous variable), which we named DIGITECNOUSE.

In general, that is, for all types of technologies studied taken in an aggregate manner, according to the model (Table 6), the number of family members, the number of working members, the size of the farm, education, perceived usefulness and knowledge of digital technologies are factors with a positive and significant effect on the level or degree of their use by the farmer. Likewise, the availability of technologies has a positive effect on the extent of their use by farmers, while it does not result in a significant effect the agriculture is or not unprofitable; the same for the capital. Gender also seems to have nothing to do with the level of use of digital technologies.

For example, the coefficient 0.08 next to the variable

Table 5. Knowledge, use, utility and willingness to use digital technologies (averages) by utility as a dummy variable

IntentionUse2Dum	DIGIKNOWL	DIGITECNOUSE	UTILITY
0	0.69	0.42	0.96
1	1.58	0.73	2.21
Total	1.35	0.62	2.03

Source: Authors' results, 2024

Table 6. OLS (Ordinary Least Squares) method, Dependent variable: DIGITECNOUSE

Heteroskedasticity-robust standard errors, variant HC1

Variable	Coefficient	Std. Error	z	p-value	
MEMBER	0.0847368	0.0168298	5.035	<0.0001	***
GEN	0.0227215	0.106902	0.2125	0.8317	
AGE	−0.00639190	0.00241160	−2.650	0.0080	***
EDU	0.130561	0.0289141	4.515	<0.0001	***
EMPLO	−0.599331	0.0790468	−7.582	<0.0001	***
TOTOWNL	0.00490804	0.00263163	1.865	0.0622	*
NOPROFIT	−0.0134339	0.0964715	−0.1393	0.8893	
NOCAP	−0.100282	0.148515	−0.6752	0.4995	
UTILITY	0.278873	0.0472517	5.902	<0.0001	***
DIGIKNOWL	0.546210	0.0283684	19.25	<0.0001	***
WORKMEM	0.0882935	0.0189659	4.655	<0.0001	***
AVAILABLE	0.246070	0.0314172	7.832	<0.0001	***

Source: Authors' results, 2024

Table 7. OLS, Dependent variable: DIGITWILL

Heteroskedasticity-robust standard errors, variant HC1

Variable	Coefficient	Std. Error	z	p-value	
MEMBER	−0.0144900	0.0201785	−0.7181	0.4727	
GEN	0.157255	0.0967379	1.626	0.1040	*
AGE	−0.0163120	0.00210899	−7.735	<0.0001	***
EDU	0.220623	0.0270910	8.144	<0.0001	***
EMPLO	−0.113758	0.0678507	−1.677	0.0936	*
TOTOWNL	0.00288550	0.00145500	1.983	0.0473	**
NOPROFIT	0.0651670	0.0683315	0.9537	0.3402	
NOCAP	−0.281704	0.177826	−1.584	0.1132	
DIGITECNOUSE	0.153799	0.0257774	5.966	<0.0001	***
DIGIKNOWL	0.263341	0.0255170	10.32	<0.0001	***
UTILITY	0.683087	0.0485829	14.06	<0.0001	***
WORKMEM	−0.0250511	0.0195408	−1.282	0.1998	

Source: Authors' results, 2024

MEMBER shows that families with one more member use digital technologies 0.08 units more on the scale 0 to 4. The coefficient 0.546 nextin front of the variable DIGIKNOWL shows that with the increase of one unit of knowledge on the scale 0 to 4, the use of technologies is expected to increase by 0.546 units.

For the willingness of farmers to use digital technologies, we evaluated two models, a classical linear and a binomial, as possible models. The classical models for the willingness to use digital technologies (Table 7) shows that knowledge, utility, the current rate of technology use, the size of the population, education positively affect the level of willingness of the farmers to apply technology. Men tend more in this application. But the number of members in the family, the number of working members, the lack of capital and the opinion of whether or not agriculture is profitable have nothing to do. Those who work mainly on the farm have the lowest willingness.

According to the logit binomial models, where the willingness variable is IntentionUse2Dum, again the main determining variables with a positive effect on willingness are knowledge, utility, degree of actual use and education; age has a negative effect, the lack of capital also has a negative effect, while there is no effect of gender, employment or not only in the farm, the size of the farm and the opinion if agriculture is profitable or not, so all farmers, regardless of what they think about agriculture, are not significantly different in the level of the willingness to apply digital technologies in the future. The logit binomial model also allows for other comments, using odds Exp (B). Take, for example, knowledge for which odds Exp (B) = 3.76, i.e. positive, indicates that with an increase in the level of knowledge by one level, it is expected that the willingness to use technologies compared to non-use will increase by 3.76 times or 376%. If we take the age where the relative chances are negative, if the age increases by one year, it is expected that the willingness to use compared to non-use will decrease by (1–0.89) *100 = 11%.

Discussion

The topic of our article is the level and willingness of the farmers to use digital technology. This topic is very important for the great effects that the application of these technologies has in agriculture. The study uses the classical regression method, dummy logit models and the cross-tabulation method. The third method is used as a supplementary method to increase confidence in modeling results, since cross-tabulation based mainly on data grouping has the ability to eliminate some of the random effects and reveal relationships even when the model cannot do this. Of course, detailed results this method cannot provide. We mainly use unifactorial models because in the case of multifactorial models, which would naturally provide more indicators and information, the possibility of a drastic reduction in the observations obtained based on the estimation of missing observations for different variables increases greatly. The study shows that the current rate of implementation of these technologies is very low, around 0.62, while the willingness is around 1.9 on a scale of 0 to 4.

The results of the study confirm an important part of the hypothesis on the factors that positively influence the degree of implementation of these technologies, such as the size of the farm, the formal education of the farmer, knowledge of digital technologies, their usefulness as perceived by farmers, the availability of technologies and the positive effect of gender understood as more use by men is not proven. The

Table 8. Testing results of the hypothesis on the degree of application of digital technologies

Variable	The effect of the factor (+) ose (–)	Accepted (YES) or Not accepted (NO)	Testing instrument
Farm size	+	Yes	Cross-tabulation, Econometric model
Farmer education	+	Yes	Cross-tabulation, Econometric model
Gender:menuse more	+	No	Cross-tabulation, Econometric model
Increasing knowledge	+	Yes	Econometric model
Farmer perceived utility	+	Yes	Econometric model
The size of the farm family	–	No	Econometric model
Working family members	–	No	Econometric model
The belief that agriculture is profitable	+	No	Econometric model, Crosstabulation
Age	–	Yes	Cross-tabulation, Econometric model
Lack of capital	–	No	Jo modeli, Po According to crosstabulation
Employment only on the farm	+	No	Econometric model, Crosstabulation
Technology availability	+	Yes	Econometric model, Crosstabulation

Source: Authors' results, 2024

Table 9. Testing results of the hypothesis on the willingness to apply the digital technologies

Variable	The effect of the variable/factor (+) ose (–)	Accepted (YES) or Not accepted (NO)	Testing instrument
Farm size	+	Yes	Econometric model Yes, Crosstab No
Farmer education	+	Yes	Econometric model, Crosstab
Gender: men use more	+	No	Econometric model No, Crosstab Yes
Increasing knowledge	+	Yes	Econometric model
Farmer perceived utility	+	Yes	Econometric model
The size of the farm family	–	No	Econometric model
Working family members	–	No	Econometric model
The belief that agriculture is profitable	+	No	Econometric model No, Crosstab Yes
Age	–	Yes	Econometric model, Crosstab
Lack of capital	–	Yes	Econometric model, Crosstab
Employment only on the farm	+	Yes	Econometric model
Technology availability	+	No	Econometric model No, Crosstab Yes, not sure

Source: Authors' results, 2024

negative effects of age are also confirmed, while the negative effect of the size of the farming family or the number of family members working on the farm, the lack of capital (with one method, regression), and the employment of the farmer only on the farm is not proven.

It was expected that the belief in agriculture as a profitable activity would result in a significant positive effect, something that was not proven by any method. We think that the effect can be negative, depending on the point of view. Farmers may think that agriculture is a non-profitable activity, and it is not worth investing in digital technology, or on the contrary, agriculture is not a profitable activity, but investing in this technology can change the situation. There is a need for other specific studies to clarify this dilemma. It was also expected that the size of the family or thenumber of employees from the family on the farm would have a negative effect based on the logic that when the number of workers is large, the labor supply is large and the need for digital services, so also technology, can be reduced. This is not proven, so the size of the family has nothing to do with the degree of implementation of these technologies. Table 8 shows in detail the parts of hypothesis H_1 that are proven or not proven according to the two methods used.

Regarding the hypothesis about the willingness of farmers to use digital technology, the positive effect of the farm size, knowledge, benefits these technologies can bring as perceived by farmers, education, as well as the actual use of technologies in the sense that those farmers who use them tend to be more willing to work in the future as well, and of the belief that agriculture is a profitable activity in the sense that farmers who think of agriculture as profitable are more willing (proved only with the crosstabulation method). The negative effect of age is proved, for the elderly are less ready, and of the lack of capital in the sense that those who seek capital, but do not have access are less ready than others. The effect of the size of the family, the number of members who work on the farm and the employment of the farmer as the head of the family only on the farm is not proven (in fact, working only on the farm results in a positive effect, but the differences between the two categories (those who work only on farm and those who work and out of farm are minimal). Table 9 shows in detail the parts of hypothesis H_2 that are proven or not proven according to the two methods used.

Limitations

We want also to argue about some research limitations, which is the huge number of missing observations, otherwise the limited number of used data observations. In the case, we would like to estimate a multiple regression model with all the factors shown in table 6, because of missing observations only 262 data observations from a total of 938 would be possible to use. If only the variable TOTOWNL would be included in the model, we would have 265 missing observations. Missing observations restrict the use of multiple regression models. To compensate for the missing observations and multiple regressin models, we used crosstabulation as a supplementary method of analysis.

Conclusion and recommendations

The topic of this study is digitalization or digital technologies and their use by Albanian farmers. The study is based on data collected through surveys in five regions of Albania (Korçë, Kukës, Berat, Fier and Gjirokastër) for 938 farms from these areas. The research methods used in this study are descriptive and exploratory statistics as well as econometric modeling.

The purpose of the study is to evaluate the level of use of some main digital technologies and the willingness of Albanian farmers to use them in the future. In addition, the objective of the study was also to evaluate some factors that influence, hinder or promote the use of digital technologies by Albanian farmers.

The analysis shows that the aggregate degree of use of digital technologies by farmers is low, only 0.62 in the evaluation range from 0 to 4, or only 15.5% against the maximum level (4). However, their use by some farmers with a low level of education is surprising. Even the degree of willingness to use digital technologies, although much higher than the actual use, is not high (1.91, in the evaluation range from 0 to 4).

Considerable differences (gaps) between the regions are established as regards the degree of current use and the willingness to use them in the future. The best users of these technologies seem to be Korça farmers with an average level of 1.43, and with the lowest use those from Kukës with a scale of 0.07. Even when it comes to the willingness to use digital technology, there are considerable regional differences, from 2.06 in Korçë to 1.55 in Fier. The lowest degree of willingness in Fier as an area with agricultural potential is noticeable, and the rather high degree of willingness in Kukës (1.93) compared to their actual use in this region (0.07).

Knowledge and skills on digital technologies, as well as their availability when they need them, are important factors, with a positive impact on the actual level of application and willingness to apply them in the future. Larger farms and farmers with a higher level of formal education use more digital technologies. A deeper exploration shows that farms with sizes from 0.8 to 20.8 dynym (1000 m^2) use more digital technologies, when these farms make up about 56% of the total.

Based on the regression model, the lack of capital plays an insignificant role in the current degree of use of technologies, but according to the cross-tabulation it is clear that the farms that emphasize the lack of capital have a lower rate of use of technologies, although not very different. Regarding the willingness to use digital technology, it turns out that the lack of capital is a negative factor.

Farmers' awareness on the benefits of digital technologies is proven to be an important factor both for the adoption of technologies and for the willingness to use them in the future. There is also good evidence for the effect of farmers' belief in agriculture as a profitable activity in their willingness to use it in the future.

Age results as a factor with a negative effect both for current use and for the willingness of farmers to use them in the future. If would speak in the context of aging in the agricultural population of the country, we could say that this problem is of critical importance for the introduction of digital technologies in agriculture.

Based on the study, if in the future the level of implementation of digital technologies should increase, the focus of attention should be knowledge and digital skills of farmers, the benefits they attribute to these technologies, availability of the technologies and access to capital. Of course, the increase in the size of the farm generates additional incentives for the use of these technologies.

Improving the knowledge of farmers on digital technologies can be achieved through such measures as seminars, trainings, increasing access to advisory services and reducing their cost, even through subsidizing a part of it.

Efforts to convince farmers that agriculture is an economic activity that can bring real economic benefits for them is of particular importance, because the belief in agriculture as a profitable activity is vital both for the survival of the sector and for its role in the national economy and in food security of the population. To increase confidence, farmers must sell their products at a fair price to cover costs and ensure a profit. The solution is to support them with finance, assistance, knowledge and advice to use the right techniques, inputs, methods and technologies for production, to increase yields and increase the efficiency of expenses.

On the other hand, to encourage the sale of farm products, a special role can paly ensuring market transparency and eliminating unfair competition, from imported inputs and products in particular. Market monitoring and periodic analyzes would make it possible to identify problems and proposing measures and instruments to ensure fair competition and market transparency that would help establish fairer price levels for farmers. Digitalization has an important role to play in this direction.

In addition to strengthening the role of Agriculture Knowledge and Information System (AKIS), in the sense of its greater and more effective role in advising farmers, disseminating information and knowledge, R&D and experimentation as well as strengthening the digital capacities of human resources, it would also be important to improve the sistem in terms of its approach, standards, procedures, capacities and cooperation between the actors of the system. On the other hand, in cases that would be deemed necessary, subsidizing the costs of farm production would also help to increase the competitive capacity of farmers in the market and increase their confidence in agriculture as a profitable economic activity.

Digitalization affects the improvement of farmer' information for all links of the value chain, marketing and the facilitation of the sale of products or the purchase of inputs, competition in the market, farm management by adopting better management models, facilitating and promoting innovations, regarding new products and services, etc. Studies show that without the cooperation of all actors in the value chain, it would be difficult for digital technologies to have a full effect.

Digital technologies applied in the rural sector, are an important instrument for the empowerment and engagement of youth and women in this sector. Stakeholders, such as government, universities and non-governmental organizations (NGOs), can play an important role by providing training to farmers for using digital technologies in their activities.

Tough challenges to increasing the degree of application of digitalization are the aging and old age of farmers, their difficulties to fulfill a profitable economic activity, the small size of the farm, depopulation of rural areas and low digital skills of the most aged part of rural population in particular. Ageing and depopulation, as literature points out (Gu, et al., 2022), not to forget climate changes, are at the same time serious threads to sustainability of rural areas including agriculture. In this context the first actions to take woud be improving farmers' awareness about the importance and effectiveness of digital technologies through wellorganized campaigns, seminars, brochures, leaflets, visits to farmers for experience sharing and good examples, etc. can help increase the use and benefits that farmers can gain from using digital technologies

Cooperation between government institutions, international organizations, researchers, academic communities as well as business actors, is very important for the exchange knowledge and experiences as well as to promote best practices for the digitalization of agriculture.

Experience shows that firms in poorer countries adopt digital technologies much more slowly than expected. Moreover, growth and better services may not happen if not improve business regulations, skills development systems, and public sector governance. Thus, the design and implementation of programs and national strategies for digital agriculture should be oriented towards achieving digital transformation and realizing the Sustainable Development Goals (SDGs) in the rural sector.

As the OECD points out, policy has the task of helping to eliminate or reduce barriers to the adoption of innovations and digital solutions. Among others, policy should support a competitive environment in the markets of technologies and inputs, improvement of telecommunications service, good data governance, improvement of services for farmers, support for building adequate labor force capacities.

Thus, transformative effects of digitalization, especially for small farms, cannot happen without a regulatory environment, and without an appropriate policy framework. Policymakers should design strategies and define actions aimed at developing collaborations between actors involved in the agri-food chain and the use of digital technologies to support rural development. As a result, not only farmers, but also investors and donors should become willing to invest in viable services.

The process of designing programmes to foster using of digital techmologies in our country should be comprehensive and address all the obstacles and factors of the implementation of digital technologies, as well as measures or policies to facilitate or promote their application including subsidizing certain costs. It is important that development programs take into account the needs of the country but also local conditions and characteristics.

We also emphasize the need to improve the connectivity and affordability of the Internet by the farmers, as a factor in a speedy and efficient digitalization.

Scope for further research

Analysis shows a relatively large percentage of small-scale farms and farmers with low education, who use advanced technologies such as drones, satellites, big data, Google Drive, etc. For example, 11% of farms of size 0.8 to 20.8 dynyms use drones, 13% use big data and 14% use sensors; 5% of farmers of low education level use drones, etc. This seems quite smart, but it doesn't seem convincing enough.

To clear doubts about therdre figures we propose some selected case studies at farm level. Cases to investigate should be selected from different farmer education levels, regions, and farm scale. Moreover, these studies would help to further and more indeep investigate and identify factors, difficulties and obstacles, that farmers are facing during their application, challenges on the way to and benefits derived from the use of these technologies. This would help also formulate lessons to learn and experiences to distribute among farmers, as well as to propose policy measures to support digitalisation of agriculture. This could also help clarify some doubts about the use of modern digital technologies by small-scale farmers and by low, but not only, educational level farmers.

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