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Factors of innovations adoption in the Albanian agricultural sector – an econometric approach

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Abstract

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This study deals with effects as well factors and barrier to innovation adoption in Albanian agriculture. The objective of the study is to provide a measure of the innovation level based on a number of basic categories of agricultural innovations, and identify factors or barriers that impact the adoption of innovations in the context of agricultural sector in Albania. To carry out the study we used primary data collected through direct survey of a small sample of 110 farmers in one of the most agriculture potential areas in western lowland Albania, Fieri region. We used descriptive statistics and econometric modeling to analyze data and draw conclusions.

Based on a 5 year reference period, the aggregate level or index of innovation resulted 1.28, whereas for digital innovations/ technology use it resulted 0.89 on a scale from 0 to 3.

Major factors of innovation adoption are confirmed farmers' knowledge, poor market access to quality and low cost inputs, weak farmers' digital skills and R&D system, poor access to information knowledge and advice, not clear policy about innovation priorities, human capital, poor support to farmers in terms of finance, perception for no returns on innovation investments, etc. Farm size and farmers experience were not confirmed as factors in the case of aggregate innovation level.

At the end, to foster innovation adoption by small farmers, various policy insights and measures are recommended.

Keywords: agriculture; econometric model; efficiency; innovation; innovation factor; productivity
Jel Codes: O13; O31; Q01; Q16; Q18

Introduction

In this article we deal with the issue of innovation, more specifically with that of innovation in agriculture. Innovations and their adoption by farmers are of great importance. Why is this topic important?

The importance of adopting innovations in the agricultural sector can be explained first of all with the economic and social profile or structure of Albania. Albania is a country, where agriculture makes an important contribution to the Albanian economy. In economic terms, it contributes about 20% of the country's GDP, 37.4% of the country's work force is employed in agriculture. In agriculture operate over 300 thousand agricultural farms, 86% of which are micro and small farms of size up to 2 ha (MARD, 2022). Depopulation due to emigration, especially of young people, towards cities and outside the country, as well as aging, are currently two of the main features of the country's rural areas, and important social and economic challenges for the future.

The literature evidences that the improvement in agricultural technologies, as an aspect of the adoption of innovations, strongly affects the economic and human develop-

ment of a country (Grabowski and Self, 2006) and poverty through effects on food prices, and employment (Berdegué and Escobar, 2002).

In agriculture, as in other sectors, innovations are the main driver of productivity growth (Campuzanoet al., 2023) and the efficiency of the use of production resources (FAO, 2017).

The literature points out that the future of small farms is determined by technological and institutional innovations suitable for small farmers (Diao et al., 2023).

Other studies have shown that agricultural innovations can help improve soil quality and reduce nutrient loss, and reduce the net emission of greenhouse gases that contributes to sustainable management of agricultural ecosystems (Ogundari and Bolarinwa, 2019).

Important types of innovations in agriculture are digital ones. Digital agriculture or digitalization in agriculture is the use of detailed digital information to guide information-based decisions along the agricultural value chain" (Tomorri et al., 2024). Digital technologies can catalyze development and accelerate economic growth (Benfica et al., 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, block chain technologies, IoT, cloud computing, AI) (Nogales and Casari, 2023).

Digital technology is an opportunity to increase also the efficiency of services to farmers and their access to the market, and as a possible tool to improve the sustainability of agricultural systems (FAO, 2018; Blakeney, 2022).

WB (2016) highlights that digital technologies can raise efficiency, foster innovation by reducing transaction costs, facilitates the collection, storage, analysis and sharing of data and information, service delivery, time and cost reduction for and improving extension services to farmers, supports economies of scale thus enabling innovative business models, facilitates links between sellers and buyers, and improves agricultural supply chain management. Other effects are improved market transparency, efficient logistics, safe payment for selling products or buying inputs as well as transferring to farmers state agricultural subsidies, etc.

Important are also the effects of the adoption of innovations facing the challenges arising from the depopulation of rural areas, which currently constitute a serious threat for the sustainability of agricultural and rural development.

Innovations are of particular importance in addressing the problems arising from the aging of the population (Liu et al., 2021).

Agricultural innovations can also help in facing the challenges of climate change, in adapting to them (Akkoyunlu, 2013) without compromising economic growth (Mikler and Harrison, 2012; Michalak, 2016).

The Albanian government has been conscious of the role of innovation, as a factor for agricultural development in the conditions of great domestic and especially international competition in the framework of globalization; in the strategy of agricultural and rural development 2014-2020, it has announced the development of the agricultural innovation system, mainly through 5 CTAT (Centers for Transferring of Agricultural Technologies), which serve the transfer of technologies also according to local conditions. In addition to CTAT-s, there are also CAI (Centers of Agricultural Information), whose duty is to distribute information to farms and agribusinesses.

Need for a speedy process of innovation adoption in the Albanian agricultural sector may also arise because of its low level of the general innovation index. According to WIPO (2023), Albania has the lowest level of the innovation index in the Balkans, 25.4, from 37.5 Greece, and 60.4 the Netherlands. According to European Innovation Scoreboard the innovation index of Albania (classified as an emerging innovator country) in 2024, is only 41.8% of the EU average and 48% of the emerging innovators (EC, 2024).

In Albania, according to Ministry of Agriculture and Rural development-MARD (2022), the digitalization as well in agriculture is weak and investments in precision agriculture are rare. According to GWP (2022), precision agriculture and digitalization in agriculture are still rarely applied and mainly in fruit culture and vegetable production.

Research problem

Albanian farmers have made and are making efforts to apply various innovations in their farms. Efforts and support for their adoption and application have been made, and are being made even in the agricultural sector by the government in the context of the policy framework and of the country's agricultural development programs. However, in Albania there are still no measurements or evaluations or indicators related to the degree of adoption of agricultural innovations, whether of an aggregate nature or detailed indicators for different agro-ecological areas, different types and sizes of farms or different categories of innovations. In fact, in Albania there are data on innovation adoption provided by INSTAT (Institute of Statistics of Albania), but only for companies employing 10 or more people, but agriculture sector is not included.

Moreover, though literature as we can see later, here provides a good framework of factors/barriers to innovation adoption in agriculture, there is no researches regarding fac-

tors, the most important ones in particular, which restrict or promote the adoption of innovations in the context of Albanian agriculture. Research findings would be valuable, in addition to a better understanding of which the current situation is, for the programming of measures and policies to eliminating or reducing these obstacles and increase the level of innovations adoption in Albanian agriculture. These, as we pointed out above, would be accompanied by strong positive effects in increasing the productivity, resource efficiency, farm products competitiveness, environment protection, income of farm families, thus poverty reduction and improved living of rural residents.

Objectives

In this research, we have as objectives: a – to make an estimation of the degree of adoption of agricultural innovations of mainly technological character, as well as digital ones, at farm level in a selected area of the country; b- Identification of the main driving factors and/or barriers in the adoption of innovations by Albanian farmers; c- Based on the literature, the formulation of policy recommendations/highlights for reducing obstacles to innovations and increasing the degree of their implementation in agriculture at both farm and sector levels.

Theoretical framework

First, regarding the meaning of innovation, we refer to the Oslo Manual. The Oslo Manual 2005 defined innovation as "the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organizational method in business practices, workplace organization or external relations" (OECD-Eurostat, 2005).

According to (OECD-Eurostat, 2018; Campuzano et al., 2023), the innovation is understood as a new or improved product or process (or their combination) that differs significantly from previous products or processes, and that has been made available to potential users (product) or put into use by the unit (process).

According to FAO (2018), agricultural innovation is the process whereby individuals or organizations bring new or existing products, processes or ways of organization into use for the first time in a specific context in order to increase efficiency, competitiveness, resilience to shocks or environmental sustainability and thereby contribute to food security and nutrition, economic development and sustainable natural resource management.

Innovations are the result of some activities that are called innovation activities. Innovation activities are all development, scientific, technological, organizational, financial and commercial steps, including those related to investments in knowledge, which actually, or are intended to, lead to the implementation of innovations. These activities themselves need not be novel, but are necessary for the implementation of innovations (OECD, 2005; OECD-Eurostat, 2018).

According to the Oslo manual innovations are classified into four types or groups: product, process, organizational and marketing or commercial innovations.

Both product and process innovations are called technological innovations.

Innovation of the marketing type is the one that has to do with the marketing of a product, such as: design of a product, promotion, pricing, etc. Innovation of the organizational type is the one that deals with organizational aspects of the farm or business, such as: organization of the workplace, external relations, business practices such as supply chain management system, reporting system, quality-management system, quality standards, collaboration with other firms and universities, etc. Marketing and organizational innovations are called non-technological.

While, according to Bragdon and Smith (2015), innovations can be technical or institutional. Technical innovation refers to the development of new varieties, tools and techniques, most commonly associated with the term innovation. Institutional innovation refers to changes in relationships among actors, both within communities and between farmers and supporting actors. Institutional innovation can increase the scale of impact of technical innovation by facilitating the spread of innovation over larger areas or help achieve long-term impact of technical innovation.

Innovations originate from scientific research, but there are two types of research related to innovation: research for the generation of innovations and research for the adoption and use of innovations. From another point of view, we have two types of innovations: innovations embodied in capital goods (tractors, seeds, etc.) and intangible innovations (e.g. integrated nutrient management, integrated pest management, etc.) In terms of form, innovations can be: mechanical, biological, chemical, agronomic, biotechnological, and informational (computer technology).

But the innovation as a concept should not be understood the same as the concept of invention. Invention is the creation or the supply of knowledge, whereas innovation is the use of this knowledge, understanding with this also a set of factors which make possible the transition process from invention to innovation (Pound & Conroy, 2023).

Review of literature

There are numerous publications and statistical and econometric analyses, which focus on identifying the factors

that determine or influence the rate of adoption and application of innovations or the innovativeness of farmers.

In innovation, two types of factors operate and intertwine, external and internal. External factors are those factors that are outside the control of the farm, but are important in the creation, diffusion and adoption of innovations. These factors have to do with consumer activities, competitors and product providers, the labor market, rules and legal framework, economic and competitive conditions, the supply of different types of knowledge. Among the internal factors, the most important are the business model of the farm, its production and innovation capabilities, its financial and human resources (OECD-Eurostat, 2018).

Table 1 below summarizes the main factors that encourage or hinder, depending on the point of view, innovations in agriculture, according to the literature.

Data and Method

We use primary data on the adoption of innovations by farmers for a 5-year reference period (2020-2024), collected through a special survey through dedicated questionnaires in one of the most potential agricultural areas of the country, named Myzeqe (Fieri region). A modest sample of 110 farmers of this area was directly interviewed to obtain the necessary data on innovations. In terms of gender 90% of selected farmers were male; in terms of farm size 61% of farms have a size of less than 2 hectares, and only 8% are of size above 5 hectares; in terms of education 60% of farmers have middle education (general, or agricultural), and only 23% have high education; in terms of age only 10% of famers are under 40 years old, 50% between 40 and 59 years and 35% above 60 years old. These data show the dominance of old farmers,

Table 1. Factors of innovations adoption as by literature

Factors/barriers of agricultural innovation adoption	References
Advisory services, technical assistance, knowledge transfer, information, lack of trainings, seminars, filed visits, experience exchange activities.	Tirfe, 2014; Reij and Waters-Bayer, 2001; Annosi et al., 2022, Herrera-Arango et al., 2023; Akkoyunlu, 2013; OECD, 2001; Tomorri et al., 2024; Gutiérrez et al., 2023
Positive attitude to agriculture	Tirfe, 2014; Reij and Waters-Bayer, 2001.
Farmers' knowledge is a key issue, knowledge and information transfer, access to information	Campuzano et al., 2023; Akkoyunlu, 2013; Tomorri et al., 2024.
Availability of materials, inputs: lack or limitations, inadequate inputs, high costs or prices for inputs, low output prices for small farmers in particular, price instability	Tirfe, 2014; Herrera-Arango et al., 2023; Akkoyunlu, 2013; Diao et al., 2023; Blakeney, 2022; Tomorri et al., 2024; Campuzano et al., 2023; OECD, 2001
Experience in traditional agriculture	Tirfe, 2014
Access to transport	Herrera-Arango et al., 2023
Household size	Reij and Waters-Bayer, 2001
Small farm size/scale, amount of land	Annosi et al., 2022; Akkoyunlu, 2013; Tomorri et al., 2024; OECD, 2022; Reij and Waters-Bayer, 2001
Land tenure form	Herrera-Arango et al., 2023; Sunding and Zilberman, 2000
Uncertainties around land ownership	Tomorri et al., 2018
Age of the farmer	Reij and Waters-Bayer, 2001; Herrera-Arango et al., 2023; OECD, 2022
Gender	Annosi et al., 2022
Human capital	Reij and Waters-Bayer, 2001; Annosi et al., 2022, Herrera-Arango et al., 2023; Akkoyunlu, 2013; OECD, 2001; OECD, 2022
Farming experience	Reij and Waters-Bayer 2001; Annosi et al., 2022
Akcesi ndaj kredive dhe financimi	Herrera-Arango et al., 2023; Salpina and Pagliacci, 2022; Tomorri et al., 2018.
Low farmers' investment power	Campuzano et al., 2023
Farm resources and revenues	Annosi et al., 2022; Herrera-Arango et al., 2023; OECD, 2001
Skilled labor	Campuzano et al., 2023
Market access	Herrera-Arango et al., 2023; Rapsomanikis, 2015; Smidt and Jokonya, 2022; Tomorri et al., 2024
Price competitiveness in market, unfair markets and competition	Matsunaga, 2019; Smidt and Jokonya, 2022
Product market price fluctuation	Herrera-Arango et al., 2023
Lack of or asymmetric information	Tomorri et al., 2024; Matsunaga, 2019

Table 1. Continued

Farmer attitudes towards risk, risk perception	Herrera-Arango et al., 2023
Provision of pro-poor innovations	Smidt and Jokonya, 2022
Access to and cost of innovations	OECD, 2022
Lack of complementary factors such as human, financial, organizations, managerial capital that produce the innovation paradox.	Matsunaga, 2019
Policies that promote innovation	Campuzano et al., 2023
High priority of the subject in the country	Campuzano et al., 2023
Unfavorable regulation, complexity and regulatory burden, weak or inappropriate rules	Campuzano et al., 2023; Herrera-Arango et al., 2023; EY, 2019;Matsunaga, 2019
Institutional and community support support	Herrera-Arango et al., 2023
Corruption	Matsunaga, 2019
Government support, subsidies for farmers	Campuzano et al., 2023; Annosi et al., 2022
Support of smart technologies	Smidt and Jokonya, 2022
Fiscal and macroeconomic policies	Sunding, and Zilberman, 2000
Weak infrastructure	Campuzano et al., 2023
Technology suitable to local context	Akkoyunlu, 2013
Cost of information and knowledge transfer	Akkoyunlu, 2013; OECD, 2001
High implementation costs of innovations	Campuzano et al., 2023
Return on investment uncertainty	Campuzano et al., 2023
No perception of benefit from implementing innovations	EY, 2019
Research partnerships	Akkoyunlu, 2013
Investment in R&D	Takacs-Gyorgy, 2012; Alston et al., 2022; OECD, 2001; Campuzano et al., 2023
Weak access to or nonparticipation in economic and social network (that promote mutual confidence, cooperation, and negotiation power that reduce transaction costs	Bragdon and Smith, 2015
Mutual among farmers confidence	Bragdon and Smith, 2015
Collective action, collaboratin and dialogue among farmers	Diao et al., 2023; Akkoyunlu, 2013; Smidt and Jokonya, 2022; Annosi et al., 2022; Tomorri et al., 2024
Transaction costs	Diao et al., 2023.
Weak contact networks, lack of farmers' contacts	Campuzano et al., 2023
Mass media exposure	Reij and Waters-Bayer, 2001
Participation in social activities	Annosi et al., 2022
Cooperation between public and private institutions	Annosi et al., 2022
Positive attitude to institutions	Annosi et al., 2022
Dialogue and collaboration between stakeholders of the value chain for the exchange of knowledge, information, experiences and technologies	Clavel, 2011
Partnerships, links and interaction between different actors	Annosi et al., 2022, Clavel, 2011
Digitalization, digital and TIC skills and knowledge, digital and technology-driven technologies	Smidt and Jokonya, 2022; EIB, 2019.
High speed Internet connectivity	OECD, 2022
Perception of risk about climate change	Annosi et al., 2022,
Consumer health and sustainability are key drivers to innovation	EIB, 2019
Percept value/cost of technologies, transaction costs and net benefits	Diao et al., 2023; OECD, 2022; Takacs-Gyorgy, 2012; Sunding and Zilberman, 2000.
Innovation systems	Akkoyunlu, 2013
Skills to manage risk	Blakeney, 2022
Pressures from consumers, NGOs, media and the public	OECD, 2001
Farmers' innovation culture	Mileva and Georgieva, 2022

Table 1. Continued

User friendliness	OECD, 2022
Quality of life gains	OECD, 2022
Distance to region's center	Sunding, and Zilberman, 2000
Distance to markets	Diao et al., 2023
Capacity to benefit from innovations	Diao et al., 2023
Failures in production and marketing coordination	Diao et al., 2023
Demand for innovations	Diao et al., 2023

Source: Authors' own elaboration

micro and small size farms, and male farmers, what also is typical for the agriculture sector in general.

We use descriptive statistics, such as averages or medians, as well as econometric modeling (regression) to evaluate the degree of implementation of agricultural innovations and identify factors with significant effects on this degree. The model regression we use has the form:

$$\mathbf{Y = AX + e}$$

In this model, Y is the dependent variable, A is a vector of parameters and X is the matrix with the values of the independent variables. *e* it is the error term. The model is estimated with the OLS (Ordinary Least Squares) method with Heteroschedasticity-robust standard errors. For more information about estimation and comments of econometric models see (Wooldridge, 2009).

By hypothesis, each of the independent variables included in the study have a significant impact on the dependent variables (INNOV in the case of innovation in general, and on DIGITEK in the case of digital technologies).Table 2 summarizes the main variables for which data were obtained during the interviews with the farmers and the two dependent variables.

All variables are measured on a Likert scale: Not true = 0; Little true = 1; Enough true = 2; Absolutely true = 3;

Table 2.Variables, their code and measurement scale

Variables	Code	Measurement scale
Dependent variables		
General innovation adoption degree	INNOV	Ratio
Using digital technologies such as sensors, GIS, online platforms, etj.	DIGITECH	Ratio
Independent variables, or factors		
Farmers' age	AGE	Ratio
Farmers' education level	EDU	Nominal
Farming experience	EXPER	Ratio
Gender	GEN	Dummy
Market information is missing	INFOLACK	
I used new/improved or climate resistant seeds, seedlings and pesticides/herbicides	INPUT	Ratio
Knowledge and information	KNOWL	Ratio
Policy framework for innovation does not exist or is poor	LACKPOLICYFRAMEW	Ordinal
I used New/Improved breeds of animals/bird	LIVESTOCK	Ratio
Poor access to inputs market	LOINPUTACCESQUAL	Ordinal
Qualification of farmers and other farm workers is low	LOWFARMQUAL	Ordinal
Return on innovation investment is not sure	LOWINVESTRETURN	Ordinal
I used Integrated pest management, Integrated nutrient management, and practices of organic and conserving, agriculture, smart irrigation, green fertilization, etc.	METHOD	Ratio
No clear innovation priorities in agriculture	NOPRIORITIESTOINOV	Ordinal
Number of farm members working out of the farm	OUTFARMWORK	Ratio
Number of farm members fully employed on farm	PERMAWORK	Ratio

Table 2. Continued

Access to knowledge is weak	POORACCESKNOWL	Ordinal
Climate related risk awareness is weak	POORAWARNESS	Ordinal
On farm infrastructure is weak	POORFARMINFRA	Ordinal
Support to farmers from the commune is weak	POORSUPPORT	Ordinal
Access to training and advice is weak	POORTRAINADVICE	Ordinal
Low quality of seeds/seedlings and other inputs, high cost of seeds/seedlings, fertilizers, etc.	QUALCOST	Ratio
Cost of seeds/seedlings is high	SEEDHIGHCOST	
Quality of seeds and seedlings is low	SEEDLOWQUAL	Ordinal
Farm size	SIZE	Ratio
Land ownership is unsecure	UNSECPROP	Ordinal
R&D investments and agricultural research are weak	WEAKAGRRESEARCH	Ordinal
Farmers' internet skills are weak	WEAKDIGITSKILL	Ordinal
Internet connectivity in rural areas is weak	WEAKINTERNET	Ordinal
Knowledge about and support to climate smart technologies are weak	WEAKSMARTEK	Ordinal

Source: Authors' own elaboration

except for: education that is measured on a nominal scale: 1 = Low education; 2 = Agricultural middle education; 3 = Other middle education; 3 = Agricultural high education; 4 = Other Higheducation; age, size and experience are measured on ratio scale; and the variables listed below; these are averages of ordinal variables as clarified below.

METHOD = Average scores for: Integrated management of plants, nutrients, organic farming, integrated farming, conservation farming, smart irrigation, green manure, etc.

KNOWL = Average Scores for: Insufficient agricultural knowledge and skills; poor access to knowledge for farmers; poor access to advice and training; poor knowledge and support for climate smart technologies; qualification of farmers, and agricultural workers is low.

INPUT = Average scores for: I used new/improved seeds, seedlings, or climate-resistant cultivars.

DIGITECH = Average scores for variables: I have applied sensors; automats or the Internet to collect information about humidity, temperature, soil nutrients for plants; automatic feeding and cleaning of animals; automatic milking of animals; (GIS), online platforms for markets, the Internet and online platform for price information.

LIVESTOCK = Average of: I used automated feeding, and milking.

INNOV = Innovation degree as an average of variables: INPUT, METHOD, DIGITECH, and LIVESTOCK.

QUALCOST = Average score for variables: Low quality of seeds/seedlings and other inputs, high cost of seeds/seedlings, fertilizers, etc.

Results

Table 3 below summarizes basic statistics for the variables used in the analysis. As can be seen, the general rate of implementation of the innovations of interest, for the 5-year reference period 2020-2024, is 1.28, or as much as 47% of the maximum possible. The rate of implementation of digital technologies of interest (e.g. we have not shown interest in robotics or big data or satellites, etc.) is 0.30 or 30% of the maximum possible.

Table 4 below summarizes the basic results of OLS econometric estimation for the factors of innovation adoption in general in the studied area. Note that we have expressed the variable "education" by a number of binomial variables: DEDU_1 = 1 if Low, 0 otherwise; DEDU_2 = 1 if Agricultural middle, 0 otherwise; DEDU_3 = 1 if Other Middle, 0 otherwise; DEDU_4 = 1 if Agricultural high, 0 otherwise; DEDU_5 = 1 if other high, 0 otherwise.

We can see that the level of knowledge and access to them, digital skills and connectivity, factors related to the quality and cost of inputs, as well as the perception that innovations are not of interest to due to weak returns on investments for them, the low level of farmers' awareness about climate change related risks, etc. It can also be noted that the lack of strategic political priorities for innovations has a significant impact on the innovative behavior of farmers. It is also noticed that older farmers in general are less willing to adopting innovations.

In relation to education there is a significant difference regarding innovation adoption between farmers with low

Table 3. Summary of basic statistics

Variable	Mean	Median	S.D.	Min	Max	Mean/ Max
AGE	54.40	55.00	11.90	20.00	95.00	0.57
DIGITECH	0.89	0.86	0.67	0.00	3.00	0.30
EXPER	23.70	22.00	10.80	4.00	50.00	0.47
GEN	0.90	1.00	0.30	0.00	1.00	0.90
INFOLACK	1.58	2.00	0.96	0.00	3.00	0.53
INNOV	1.28	1.24	0.50	0.28	2.75	0.47
INPUT	1.83	1.80	0.58	0.40	3.00	0.61
KNOWL	1.65	1.75	0.63	0.20	3.00	0.55
LACKPOLICYFRAMEW	2.03	2.00	0.84	0.00	3.00	0.68
LIVESTOCK	0.74	0.50	0.83	0.00	3.00	0.25
LOWFARMQUALIFIC	1.63	2.00	1.00	0.00	3.00	0.54
LOWINPUTACCESQUAL	1.87	2.00	0.86	0.00	3.00	0.62
LOWINVESTRETURN	2.00	2.00	0.95	0.00	3.00	0.67
METHOD	1.10	1.04	0.56	0.20	3.00	0.37
NOPRIORITIESTOINOV	2.02	2.00	0.80	0.00	3.00	0.67
OUTFARMWORK	0.98	1.00	1.15	0.00	6.00	0.16
PERMAWORK	2.45	2.00	1.35	0.00	12.00	0.20
POORACCESKNOWL	1.55	2.00	0.91	0.00	3.00	0.52
POORAWARNESS	1.73	2.00	0.93	0.00	3.00	0.58
POORFARMINFRA	1.65	2.00	0.98	0.00	3.00	0.55
POORSUPPORT	1.82	2.00	1.02	0.00	3.00	0.61
POORTRAINADVICE	1.78	2.00	0.85	0.00	3.00	0.59
QUALCOST	1.92	2.00	0.664	0.500	3.00	1.92
SEEDLOWQUAL	1.64	2.00	0.99	0.00	3.00	0.55
SEEDHGHICOST	2.12	2.00	0.912	0.000	3.00	2.12
SIZE	30.80	15.00	47.80	1.60	250.00	0.12
UNSECPROP	1.76	2.00	1.17	0.00	3.00	0.59
WEAKAGRRESEARCH	1.97	2.00	1.02	0.00	3.00	0.66
WEAKDIGITSKILL	1.70	2.00	1.03	0.00	3.00	0.57
WEAKINTERNET	1.52	1.00	1.15	0.00	3.00	0.51
WEAKSMARTEK	1.94	2.00	0.91	0.00	3.00	0.65

Source: Authors' calculation

education and those with other education, between farmers with middle agricultural and the other ones, and between agricultural high education and those with other education. Having other than agricultural middle or high education doesn't have any impact on the level of innovation adoption. These results emphasize how important is agricultural education.

Table 5 below summarizes basic results of OLS econometric estimations for the factors of digital innovation (digital technologies) adoption in agriculture in the studied area. From Table 5, we notice that factors such as farmer's qualification, agricultural knowledge, training and advice, support to farmers, digital skills of farmers, quality of internet connectivity, farm size, expressed and supported priorities for innovations, farmers' awareness about climate change risks, access to information, etc., are significant factor for digital innovation adoption. As Table 2 shows, they have a lot of space for improvement.

In relation to education, the above results tell that there is a significant difference regarding digital technology in-

Table 4. OLS, Dependent variable: INNOV (Heteroskedasticity-robust standard errors)

	Coefficient	Std. Error	z	p-value	
AGE	−0.007869	0.0044283	−1.777	0.0756	*
EXPER	−0.003032	0.0053116	−0.5709	0.5680	
INFOLACK	−0.177319	0.0444187	−3.992	<0.0001	***
KNOWL	−0.220672	0.0707756	−3.118	0.0018	***
LOAINPUTACCESQUAL	−0.114654	0.0567094	−2.022	0.0432	**
LOWINVESTRETURN	−0.147409	0.0585192	−2.519	0.0118	**
NOPRIORITIESTOINOV	−0.154053	0.0705567	−2.183	0.0290	**
OUTFARMWORK	0.103367	0.0398682	2.593	0.0095	***
PERMAWORK	−0.025917	0.0389196	−0.6659	0.5055	
POORACCESKNOWL	−0.108762	0.0595325	−1.827	0.0677	*
POORAWARNESS	−0.158448	0.0487927	−3.247	0.0012	***
POORFARMINFRA	−0.126821	0.0504482	−2.514	0.0119	**
QUALCOST	−0.260464	0.0728820	−3.574	0.0004	***
SEEDHIGHCOST	−0.173484	0.0524571	−3.307	0.0009	***
SEEDLOWQUAL	−0.133183	0.0522539	−2.549	0.0108	**
SIZE	−0.001293	0.0009764	−1.325	0.1853	
UNSECPROP	−0.084966	0.0432075	−1.966	0.0492	**
WEAKDIGITSKILL	−0.081267	0.0485575	−1.674	0.0942	*
WEAKINTERNET	−0.076155	0.0416133	−1.830	0.0672	*
WEAKSMARTTEK	−0.126811	0.0549165	−2.309	0.0209	**
EDU					
DEDU_1	−0.303530	0.114036	−2.662	0.0078	***
DEDU_2	−0.162976	0.0939989	−1.734	0.0830	*
DEDU_3	0.010185	0.0998535	0.102	0.9188	
DEDU_4	0.434947	0.189190	2.299	0.0215	**
DEDU_5	0.168367	0.121281	1.388	0.1651	

Source: Authors' estimation

Note: Variables with negative signs indicate a positive effect of the respective variable on the innovation rate. When $p < 0.1$ the effect is significant. For example, if the level of awareness increases by one unit, then the rate of adoption of innovations is expected to increase by 0.158 units.

novation between farmers with low education and those with other education, between farmers with middle agricultural and the other ones, and between agricultural or other high education and the rest of farmers. Having other than agricultural middle or high education doesn't have any impact on the level of innovation adoption. These results emphasize importance of middle agricultural, and both agricultural and non-agricultural high education.

Discussion

The topic of this study is the adoption of agricultural innovations by Albanian farmers. The implementation of innovations is very important for the sustainable rural development of the country with great effects also in other sectors of the economy such as trade, agro-processing, tourism, etc., in increasing farm productivity, efficiency and competitiveness, income and standard of living, as well as in the protection of nature.

We use descriptive statistics to evaluate the level or degree of adoption of innovations by Albanian farmers in one of the most agricultural areas of the country. We use econometric modeling to identify which of the factors of interest have a significant positive or negative impact on the level of adoption of innovations in general and digital ones in particular.

The research revealed that the level of adoption of agricultural innovations for the period 2020–2024 in general was

Table 5. OLS estimation, Dependent variable: DIGITECH (Heteroskedasticity-robust standard errors)

	Coefficient	Std. Error	z	p-value	
EXPER	−0.007868	0.006792	−1.158	0.2467	
GEN	0.165255	0.172542	0.957	0.3382	
INFOLACK	−0.226497	0.061955	−3.656	0.0003	***
LACKPOLICYFRAMEW	−0.162861	0.111270	−1.464	0.1433	
LOWFARMQUALIFIC	−0.140151	0.068771	−2.038	0.0416	**
LOWINVESTRETURN	−0.108942	0.085197	−1.279	0.2010	
METHOD	0.590803	0.126242	4.680	<0.0001	***
NOPRIORITIESTOINOV	−0.165734	0.099374	−1.668	0.0954	*
OUTFARMWORK	0.0995231	0.058370	1.705	0.0882	*
POORACCESKNOWL	−0.274873	0.073468	−3.741	0.0002	***
POORAWARNESS	−0.264140	0.063627	−4.151	<0.0001	***
POORSUPPORT	−0.117382	0.069302	−1.694	0.0903	*
POORTRAINADVICE	−0.174817	0.074882	−2.335	0.0196	**
INPUT	0.210701	0.124322	1.695	0.0901	*
SIZE	−0.002648	0.001201	−2.204	0.0275	**
WEAKAGRRESEARCH	−0.198732	0.069598	−2.855	0.0043	***
WEAKDIGITSKILL	−0.215829	0.062722	−3.441	0.0006	***
WEAKINTERNETCONNECT	−0.140835	0.053590	−2.628	0.0086	***
EDU					
DEDU_1	−0.299979	0.127684	−2.349	0.0188	**
DEDU_2	−0.217367	0.118870	−1.829	0.0675	*
DEDU_3	−0.081569	0.143804	−0.567	0.5706	
DEDU_4	0.706635	0.239617	2.949	0.0032	***
DEDU_5	0.374077	0.172432	2.169	0.0301	**

Source: Authors' estimation

Note: Variables with negative signs indicate a positive effect of the respective variable on the innovation rate. When $p < 0.1$ the effect is significant.

about 1.28, and 0.3 for digital innovations, against a maximum of 3.

In relation to innovation in general (INNOV), he research revealed that a considerable number of factors, from farmers' knowledge and access to them, information, education, priorities for innovation in the form of policies and instruments to support agricultural innovations, digital knowledge and skills, internet connectivity, unsecure property rights, quality and cost of inputs, etc. have effect on increasing the adoption rate. Farmers' age has a negative effect that is older farmers tended to be less innovative. The most important factors resulted to be knowledge, information, quality and cost of agricultural inputs including seeds and education level of the farmer. It is not confirmed the influence of the farm size, digital skills and connectivity, and farming experience of the farmer, which according to the literature were expected to happen.

Regarding the size, we argue that regardless of the differences in their size, all the surveyed farms, with some rare exceptions, are small, with an average size of about 3 ha and a median of 1.5 ha, so half of the farms have a size of less than 1.5 ha. In our sample, 75% of farms were under 3 ha; only 9% of farms were of size over 7 ha. The size effect could be expressed more clearly if we had more large farms, and a larger sample.

In the case of farmer's experience, the reason is that the overwhelming majority of farmers have, as the calculations show, sufficient experience in agricultural work, and in this case the non-confirmation of its effects was expected.

The lack of a significant effect of digital skills and connectivity on innovation can possibly be explained by farmers' under evaluating of its role in the generation and adoption of other types of innovations, such as technological ones. However, the results show a positive result of this factor, although not enough significant ($p = 0.11$).

In relation to digital innovation (DIGITECH), many factors resulted impactful, such as knowledge, information, digital skills, education, farmer qualification, support and advice, internet connectivity, etc., but the most important are information, knowledge, digital skills and connectivity, farmer's education, and previous experience in using new or improved seeds/inputs, technologies and practices. Some

factors such as policy framework, farming experience, gender and investment returns did not prove to be significant. In the case of the policy framework, the lack of a significant effect can possibly be explained by the farmers' not understanding of the role of this factor in innovation, although here too a negative effect of the lack of policy framework is observed with $p = 0.14 < 0.1$. Despite the insignificant role of returns of the investment in digital technology on the level of digital innovations, the results show a negative effect, but not enough significant ($p = 0.2$). Effect of gender is not significant, but male farmers tend to using digital technologies more.

Conclusions

The topic of this study is innovation in Albanian agriculture. The purpose of the study is to evaluate the aggregate rate of adoption of innovations in agriculture and identify its encouraging or hindering factors in the context of one of the areas with agricultural potential in the country, the area of Myzeqe.

On the basis of the data with choices obtained through structured interviews with farmers in the area, we calculate and use descriptive statistics to evaluate the level of innovation, as well as the regression method to identify the factors that according to the farmers have a positive or negative impact on the level of the adoption of innovations.

Estimates show that the general rate, that is, for the main types of innovations taken together, is 1.28, while the adoption rate of digital innovations, for the types taken into consideration, for the 5-year reference period 2020 - 2024, is 0.89.

In relation to innovation in general, the research revealed that a considerable number of factors, from farmers' knowledge, information, education, lack of priorities for innovation in the form of policies and instruments to support agricultural innovations, digital knowledge and skills, unsecure property rights, quality and cost of inputs, training and advice, etc., which have effects on increasing the adoption rate. Farmers' age has a negative effect that is older farmers tended to be less innovative. It is not confirmed the influence of the farm size, digital skills and connectivity, and farming experience of the farmer.

The quality of internet connectivity, the performance of the R&D system also has an important role in the scale of digital innovations adoption.

The size of the farm results not significant in the case of innovation in general, but it is significant in the case of digital innovations. The degree of innovation in agricultural inputs (new seeds, etc.) and the support for innovations seem to have an important role in the degree of digital innovations.

In relation to digital innovation, many factors resulted effective, such as knowledge, information, digital skills, education, farmer qualification, support and advice, internet connectivity, etc. but the most important are information, knowledge, digital skills and connectivity, farmer's education, and previous experience in using new or improved seeds/inputs, technologies and practices. Some factors such as policy framework, farming experience, gender and investment returns did not prove to be significant.

In terms of adoption-related policy, we would recommend policies to improve digital literacy, improved internet connectivity and affordability, more financial and technical support to farmers and an adequate regulatory framework. Coherent and long term innovation policies are needed, where actors must participate from the first steps of the process. Albania needs a strategy for digital agriculture, with well-defined objectives, measures, support and priorities.

To make adoption possible and effective, dialogue should be at the heart of the creation and adoption of innovations. Collective action, producer groups and farmers' cooperatives can facilitate the adoption of agricultural technologies.

As literature points out (OECD, 2019), for a successful innovation long-term policies are needed where all actors, starting with the farmers and their associations, playing an active role as participators in the innovation process. Rules and frameworks are also needed for the evaluation of the entire process as well of the adoption results.

Conflict of interest

The authors declare there is no conflict of interest.

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