

Understanding the impact of Internet access on farmers' willingness to participate in farmer professional cooperatives

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Abstract: The widespread application of Internet technology in rural development has significantly facilitated the modernisation of agriculture and profoundly and positively impacts sustainable rural development. This study empirically investigates the effect of Internet access on farmers' participation in farmer professional cooperatives based on a sample of 3 349 participants from the 2020 China Rural Revitalization Survey (CRRS), using both probit regression and instrumental variable probit (Ivprobit) regression models. The results indicate that, firstly, Internet access significantly enhances farmers' participation in farmer professional cooperatives. Secondly, Internet access influences farmers' decisions to join professional cooperatives differently, with older farmers, those with less education, and non-cadre individuals being more significantly affected in their willingness to participate. The findings deepen the understanding of the relationship between digital technology and organisational participation in rural development and provide empirical evidence for formulating more targeted rural development policies.

Keywords: agricultural management organization; behavioral decision-making; China; digital technology

Research background. In the contemporary era of globalisation, the increasing importance of rural development is widely recognised as a critical element within nations' broader economic and social framework (Rodríguez-Pose and Hardy 2015). Rural development is closely linked to the economic well-being and social stability of the country, and the comprehensive revitalisation of rural areas is not only pertinent

to the livelihoods and well-being of rural residents but also exerts profound and far-reaching impacts on the overall economic growth, social harmony, and stability of the nation (Castro-Arce and Vanclay 2020). Despite undergoing significant industrialisation and urbanisation, rural China continues to exhibit traditional characteristics in its socio-economic landscape, with agriculture remaining a cornerstone of the economy

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in many regions (Li et al. 2022). Currently, Chinese agricultural development is characterised by a ‘large country, small farmer’ model, where small-scale and fragmented operations dominate agricultural practices (Zhou et al. 2020). This mode of operation constrains enhancements in production efficiency and the modernisation of agriculture, thereby also impacting farmers’ incomes and the sustainability of agricultural development (Li et al. 2024).

Therefore, the innovation of agricultural management organisational systems is crucial for overcoming the resource bottlenecks and institutional constraints necessary for agricultural modernisation and comprehensive rural revitalisation. The key to this innovation lies in enhancing the organisational level of smallholder farmers’ production and operations, thus achieving the seamless integration of smallholder farmers with modern agriculture (Huang and Liang 2018). Farmer professional cooperatives facilitate the improvement of the organisational level of smallholder production and operations, making them an ideal vehicle for integrating smallholder farmers with modern agricultural practices (Huang 2011). By introducing modern management concepts and technologies, promoting scale operations, reducing costs, and integrating markets, these cooperatives effectively drive the upgrade of agricultural industrial structures and enhance farmers’ production efficiency (Deng et al. 2010). Comprehensively speaking, the role of farmer professional cooperatives in rural development extends beyond the economic dimension; it also encompasses enhancements in social, environmental, and overall national competitiveness, and the development and expansion of these cooperatives are not only imperative for the rural revitalisation strategy but also constitute a significant component of global agricultural sustainable development (Dong et al. 2019).

Nevertheless, the low willingness of farmers to participate in farmer professional cooperatives represents a significant obstacle in their developmental trajectory. On the one hand, social and cultural disparities contribute to a disconnect between traditional agricultural views held by some farmers and the novel cooperative models, leading to scepticism and reluctance to embrace these new forms (Bennett 1983; Niyazmetov et al. 2021). On the other hand, a limited understanding of the cooperative concept among farmers often fosters apprehension about the economic uncertainties of joining such organisations, thus inhibiting active participation (Yu and Huang 2020; Candemir et al. 2021). As the emphasis on rural and sustainable development in so-

ciety intensifies, the quest to identify effective strategies that can bolster farmers’ willingness to engage with farmer professional cooperatives has gained prominence in scholarly discourse. Previous studies have indicated that factors such as farmers’ economic interests, social background, and policy support can directly influence their attitudes towards farmer professional cooperatives (Yu and Nilsson 2021; Liang et al. 2022). Furthermore, the extent to which farmers acquire information about professional cooperatives has been academically verified as a key driver influencing their participation in farmer professional cooperatives. The acquisition of this information enables farmers to gain a profound understanding of the potential benefits, inherent risks, and operational mechanisms of cooperatives, thereby allowing them to make decisions about joining based on a comprehensive and in-depth understanding (Magesa et al. 2020; Luo et al. 2022). Therefore, actively expanding avenues for farmers to access information about farmer professional cooperatives, such as through facilitating Internet connectivity, can stimulate broader participation from them.

However, research addressing these aspects remains somewhat limited. Firstly, With the rapid development of the Internet and its significantly increasing penetration in rural areas, the Internet has provided farmers with rapid and wide-ranging access to information, giving them access to a diversity of data and perspectives, which in turn influences their decision-making intentions at the individual and household levels (Deng et al. 2022; Zeng et al. 2023). However, whether there is a correlation between farmers’ Internet use and their willingness to join farmer professional cooperatives has not yet been sufficiently empirically verified in academic research. Secondly, a wealth of sociological and psychological research on behavioural decision-making underscores a significant correlation between individual behavioural tendencies and demographic factors, including age, gender, educational level, and political affiliation. Yet, in the context of the growing prevalence of Internet platforms, the influence of these demographic variables on farmers’ inclination to participate in farmer professional cooperatives has not been comprehensively substantiated through empirical studies.

To bridge the identified research gaps, this study extensively utilised data from the China Rural Revitalization Survey (CRRS) conducted by the Rural Development Institute of the Chinese Academy of Social Sciences. The research employed probit regression models and instrumental variable probit (Ivprobit) re-

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gression models as its principal analytical tools, aiming to empirically investigate the potential correlations between farmers' Internet access and their willingness to participate in farmer professional cooperatives. The results of the study not only provide theoretical support for the field of rural development and lay the foundation for an in-depth understanding of the interaction mechanism between modern technology and agricultural organisations but also help to provide an empirical basis for the development of rural revitalisation strategies and useful policy recommendations for promoting the sustainable development of the rural economy and increasing the level of returns for farm households.

Literature review. Farmer professional cooperatives are economic cooperative organisations voluntarily formed by farmers, aiming to achieve organic integration of agricultural resources, shared risk, and collective benefits through cooperative relationships. They originated in the early stages of China's rural reform and opening up, and they serve as a significant institutional innovation in response to the transformation of agricultural production systems (Xue et al. 2021). This organisational form aims to optimise the agricultural industry chain, enhance production efficiency, increase farmers' income, and provide a flexible and sustainable development model for the process of agricultural modernisation (Zhou et al. 2020). However, certain challenges and issues have gradually emerged due to influences of factors such as organisational management, policy environment, and farmer participation (Zhang et al. 2020). Therefore, research on farmer professional cooperatives not only necessitates emphasising their successful experiences and advantages but also demands attention to potential limiting factors, with the aim of providing comprehensive theoretical and practical support for their sustainable development.

The complexity of farmers' willingness to join farmer professional cooperatives has sparked widespread scholarly interest, with researchers in this field delving into the factors influencing farmers' participation intentions. In terms of economic factors, Ahado et al. (2022) emphasised the concerns of farmers in their decision-making process regarding the trade-off between costs and benefits when joining farmer professional cooperatives. They revealed the characteristics of the group of participants in farmer professional cooperatives, and further highlighted the important influence of market opportunities and financial factors on their decision-making. Furthermore, studies

on policy and regulatory environments indicate a crucial role played by agricultural policies in encouraging and constraining the willingness of both farmer professional cooperatives and farmers to participate (Yu and Nilsson 2021). Investigations into information and technology factors posit that information and technology profoundly influence farmers' cognitive levels regarding joining farmer professional cooperatives, providing more comprehensive information and convenient communication channels, thereby shaping farmers' positive participation attitudes (Magesa et al. 2020; Luo et al. 2022). This comprehensive study lays the groundwork for a deeper understanding of the multifaceted motivations behind farmers' decisions, emphasising the importance of a thorough analysis of this complexity and offering valuable insights for related research and practical applications.

The impact of Internet access on farmers' participation in farmer professional cooperatives encompasses various dimensions. Firstly, the impetus of informatisation has rendered Internet access a pivotal means to expand farmers' awareness of farmer professional cooperatives, enhancing their understanding of economic cooperative organisations (Sheng and Lu 2020). Secondly, utilising the Internet not only heightens farmers' awareness of the agricultural production organisation but also cultivates a positive attitude towards organisational forms among farmers (Huang et al. 2022). Internet access allows farmers to gain clearer insights into the organisational structure, participation mechanisms, and profit models of cooperatives, fostering a more affirmative inclination towards organisational participation. Lastly, the Internet serves as a platform for farmers to communicate and participate, enabling access to shared experiences and providing timely feedback (Kour and Arora 2020). Through online communities and social media, farmers can exchange cultivation experiences, market information, and agricultural technologies with peers, facilitating the dissemination of information and cultivating a spirit of cooperation among rural communities (Rahman et al. 2020; Qin et al. 2022). This instantaneous interaction and information sharing not only strengthen connections among farmers but also provide diversified resource support for cooperatives, thereby propelling internal innovation and collaborative development within the cooperatives.

The literature review presented above lays a robust foundation for this research, offering critical insights and implications for the exploration of the selected

topic. However, while existing studies have explored the correlation between Internet use and participation in farmer professional cooperatives, they fall short in examining the causal relationship between Internet access and such participation. Moreover, the influence of demographic characteristics (e.g. age, gender, education level, political identity, etc.) on farmers' willingness to join these cooperatives in the context of widespread Internet platforms remains insufficiently verified. In light of these gaps, this paper aims to establish a scientific analytical framework to investigate the causal relationship between Internet access and farmers' willingness to join farmer professional cooperatives. Additionally, it seeks to assess the impact of the popularisation of Internet platforms across different demographic segments.

MATERIAL AND METHODS

Research material

Overall research framework. The research employed traditional hypothesis testing methods to empirically assess the mechanism through which Internet access behaviour influenced farmers' willingness to join farmer professional cooperatives. This empirical study comprises three main steps. Firstly, based on a literature review, the present study posited the impact relationship of Internet access on farmers' willingness to join farmer professional cooperatives. Secondly, utilising survey data from the China Rural Revitalization investigation conducted by the Rural Development Institute of the Chinese Academy of Social Sciences, this research employed a comprehensive approach, combining the probit regression model and the Ivprobit regression model, to validate the correlation between Internet access and farmers' willingness to join farmer professional cooperatives. Lastly, employing the probit regression, a heterogeneity test of respondents' demographic characteristics was conducted to gain a deeper understanding of individual differences' influence on Internet access impact.

Data source. This study employed data from the first phase of the China Rural Revitalization Survey (CRRS) conducted by the Rural Development Institute of the Chinese Academy of Social Sciences for empirical analysis. To comprehensively, objectively, and accurately understand the basic situation of rural areas and support academic and policy research on rural revitalisation, the Institute of Rural Development of the Chinese Academy of Social Sciences launched

the China Rural Revitalization Survey (CRRS). This nationwide tracking survey was based on the Chinese Academy of Social Sciences' significant economic and social survey project titled 'Comprehensive Survey of Rural Revitalization and Construction of the China Rural Survey Database'. It examined crucial aspects of rural development, including 'Rural Population and Labor Force', 'Rural Industrial Structure', 'Farmers' Income and Expenditure and Social Welfare', 'Rural Consumption', 'Rural Governance', and 'Comprehensive Rural Reform'. The inaugural large-scale survey was conducted between August and September 2020 across ten provinces and autonomous regions: Guangdong, Zhejiang, Shandong, Anhui, Henan, Heilongjiang, Guizhou, Sichuan, Shaanxi, and Ningxia Hui Autonomous Region. It covered 50 counties (cities) and 156 townships nationwide, yielding 300 village surveys and over 3 800 rural household surveys, collecting information on the family members of more than 15 000 individuals. This data contains detailed information on farmers' basic information, farmers' informatisation and e-commerce, rural population and labour force, rural industrial structure, farmers' income and expenditure, and social welfare. The richness and breadth of the data sources provide an opportunity for an in-depth analysis of the impact of Internet access on farmers' participation in farmer professional cooperatives. This extensive dataset provides an academic foundation for studying the correlation between rural revitalisation, informatisation and farmers' decision-making process.

Data filtering. This study adhered to a series of fundamental principles in constructing research data to ensure its scientific rigour and reliability. Firstly, the decision for farmers to join farmer professional cooperatives typically follows the principle of voluntariness and is conducted at the family level. In most instances across the extensive rural areas of China, the head of the household, serving as the core member in socio-economic family activities, makes principal decisions affecting family development (Liao et al. 2019; Yu et al. 2023). Thus, after considering the overall family situation, the household head makes the final decision on whether to join the cooperative. Consequently, to ensure the independence of data analysis at the family level, this study retains only the information of each household head, thereby eliminating potential data interference from other family members. Secondly, to ensure that the study subjects possessed a certain level of maturity and to avoid interference from a sample that was too

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young, individuals with household heads below the age of 16 were excluded. Additionally, to ensure data quality, samples with missing key variable information were also excluded. Through these stringent screening and processing steps, we obtained a final dataset comprising 3 349 valid entries, with a sample validity rate of 88.1%.

Research methods

Model selection. In examining the influence of Internet access on farmers' willingness to participate in farmer professional cooperatives, this study utilised two methods: the probit regression model and the Ivprobit regression model. There were two primary reasons for this choice. Firstly, farmers' participation in farmer professional cooperatives is a binary dummy variable, and the probit regression model is widely applied in handling binary choice problems. By estimating the cumulative distribution function, this model provides a good fit to the probability distribution, aiding in a nuanced understanding of the probabilistic impact of Internet access on farmers' willingness to participate in farmer professional cooperatives. Secondly, as the decision-making process for farmers to join farmer professional cooperatives involves multiple factors, potential endogeneity issues may arise due to omitted variables, among other reasons. To ensure a clear understanding of the relationship between farmers' Internet access and participation in farmer professional cooperatives, data processing needed to address challenges arising from endogeneity issues effectively. In order to mitigate potential endogeneity problems, this study adopted the village broadband penetration rate at the time of the survey as an instrumental variable for farmers' Internet access. The Ivprobit regression model was then employed to examine the impact effects. By introducing an exogenous variable highly correlated with Internet access, this method successfully addressed potential endogeneity issues, enhancing the model's inferential power regarding the causal relationship between Internet access and farmers' participation in farmer professional cooperatives.

The probit regression model is specified as follows:

$$Pr(Y_i = 1 | Net_i, X) = \Phi(\theta_0 + \theta_1 Net_i + \theta_2 X_i) \quad (1)$$

where: Y_i – participation status of household i in a specialised cooperative; Net_i – Internet access and usage situation of household i ; X_i – control variables; θ_0 , θ_1 , θ_2 – parameters to be estimated.

Model variable selection. In the regression model of this study, the primary variables included the dependent variable, independent variables, and control variables. The following provides detailed explanations for each variable:

Dependent variable. Participation in farmer professional cooperatives: The central dependent variable of interest in this study was whether households participated in farmer professional cooperatives. This information was obtained from the survey results of question var5_1 in the CRRS questionnaire, which asked: 'Has your household joined a cooperative?' For subsequent analysis, a virtual treatment was applied to the two options, assigning a value of 1 to 'yes' and a value of 0 to 'no'.

Independent variables. Internet access and usage: To investigate the impact of Internet access on households, this study categorised Internet access into various dimensions, including whether the household had Internet access and whether Internet usage occurred through devices such as smartphones or computers. Relevant information was extracted from the CRRS survey data and underwent appropriate processing for analysis.

Control variables. Individual characteristics included personal characteristics of the household head, such as gender, age, political affiliation, years of education, marital status, and whether the individual held a leadership position.

Household characteristics encompassed variables related to the household, including the number of permanent residents, household income, cultivated land area, and whether the land was subject to transfer.

Village characteristics involved variables related to the village, such as topography, whether the village was in suburban or urban areas, whether it fell under the category of impoverished villages, and the distance between the village committee and the county government.

Regional dummy variables were established to reflect the impact of regional differences on households' participation in farmer professional cooperatives.

By controlling for other potential influencing factors, this approach allowed for a more precise examination of the independent impact of Internet access. Detailed meanings and descriptive statistical results for these variables can be found in Table 1.

Data analysis. This study's data analysis process involved three critical steps to explore how Internet access influences households' willingness to join farmer professional cooperatives. In the first step, the significance of Internet access on households' willingness

Table 1. Descriptive statistical results of variables

Variable type	Variable names and definitions	Sample size	Mean	SD
Dependent	participation in a professional cooperative (1 = yes, 0 = no)	3 349	0.24	0.43
	Internet access (1 = yes, 0 = no)	3 349	0.91	0.28
Independent	use of smart phone to access Internet (1 = yes, 0=no)	3 349	0.90	0.30
	use of computer to access the Internet (1 = yes, 0 = no)	3 349	0.31	0.46
	age (years)	3 349	55.73	10.93
	gender (1 = male; 0 = female)	3 349	0.94	0.24
	marital status (1 = married; 0 = other)	3 349	0.92	0.27
	educational attainment (years)	3 349	7.82	3.16
	political profile (1 = Communist Party member, 0 = other)	3 349	0.23	0.42
	cadre status (1 = yes, 0 = no)	3 349	0.19	0.39
	number of household residents (persons)	3 349	4.08	1.56
	total area of operating land (acre)	3 349	22.03	77.98
	whether there is land transfer (1 = yes, 0 = no)	3 349	0.53	0.50
Control	whether poor household (1 = yes, 0 = no)	3 349	0.18	0.38
	total annual household income (EUR)	3 295	10 727.19	273 760.30
	terrain of the village (1 = plain, 2 = hilly, 3 = mountainous, 4 = semi-mountainous)	3 349	1.93	0.91
	whether it is an urban suburb (1 = yes, 0 = no)	3 349	0.20	0.40
	distance of the village council from the county government (km)	3 349	23.73	16.83
	whether it is a poor village (1 = yes, 0 = no)	3 349	0.30	0.46
	village is located in eastern China (1 = yes, 0 = no)	3 349	0.36	0.48
	village is located in central China (1 = yes, 0 = no)	3 349	0.20	0.40
	village is located in western China (1 = yes, 0 = no)	3 349	0.44	0.50

Source: Authors' own elaboration based on data from China Rural Revitalization Survey (CRRS)

to join farmer professional cooperatives was explored through the probit regression model. The second step involved conducting tests on the impact effects results using the Ivprobit regression model. In the third step, a probit regression was utilised to perform a heterogeneity test on the demographic characteristics of the respondents, investigating differences in the impact of Internet access on households' willingness to join farmer professional cooperatives based on various demographic features. All these data analysis steps strictly adhered to the scientific method and were conducted with the support of Stata software to ensure the scientific rigour and credibility of the experimental results.

RESULTS

Probit regression. Table 2 presents the results of the probit regression model. It can be concluded that, after controlling for other factors, Internet access sig-

nificantly influenced households' willingness to join farmer professional cooperatives ($P < 0.01$). Moreover, both using a smartphone for Internet access and using a computer for Internet access had significant effects on households' willingness to join farmer professional cooperatives ($P < 0.001$).

Of the control variables, the educational level, political affiliation, poverty status, and leadership position of households, as well as the geographical location of the rural area in which they resided, all exhibited significant effects on whether households joined farmer professional cooperatives. However, gender, age, and marital status of households did not show a significant impact on households' participation in farmer professional cooperatives.

Ivprobit regression. To address potential endogeneity issues in the key variables, this study introduced the instrumental variable 'village broadband household penetration rate' on top of the baseline regression and utilised the Ivprobit regression model

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Table 2. Benchmark regression results for model estimation of the effect of Internet access on farmers' willingness to participate in farmer professional cooperatives (Probit regression)

Variable	Participation in farmer professional cooperatives		
	Internet access	Accessing the Internet with a smartphone	Internet access using a computer
Internet access	0.0834** (–0.0326)	–	–
Accessing the Internet with a smartphone	–	0.0899*** (–0.0291)	–
Internet access using a computer	–	–	0.0549*** (–0.0166)
Age	–0.0011 (–0.0008)	–0.0010 (–0.0007)	–0.0013* (–0.0007)
Gender	0.0075 (–0.0325)	0.0086 (–0.0325)	0.0065 (–0.0325)
Marital status	–0.0010 (–0.0298)	–0.0013 (–0.0298)	0.0011 (–0.0297)
Educational attainment	0.0044* (–0.0026)	0.0044* (–0.0026)	0.0041 (–0.0026)
Political profile	0.0718*** (–0.0182)	0.0717*** (–0.0182)	0.0673*** (–0.0182)
Cadre status	0.0796*** (–0.0188)	0.0799*** (–0.0188)	0.0783*** (–0.0189)
Family size	0.0033 (–0.0051)	0.0031 (–0.0051)	0.0042 (–0.0050)
Total area of land under management	0.0002* (–0.0001)	0.0002* (–0.0001)	0.0002* (–0.0001)
Land transfer	0.0884*** (–0.0149)	0.0884*** (–0.0149)	0.0852*** (–0.0149)
Poor household	0.0792*** (–0.0193)	0.0789*** (–0.0193)	0.0810*** (–0.0193)
Total annual income of the family	–0.0251 (–0.0326)	–0.0306 (–0.0325)	–0.0253 (–0.0340)
Topography of the village	–0.0104 (–0.0090)	–0.0097 (–0.0090)	–0.0095 (–0.0090)
Urban suburb	0.0500*** (–0.0188)	0.0508*** (–0.0188)	0.0455** (–0.0189)
Distance of the village committee from the county government	0.0018*** (–0.0005)	0.0018*** (–0.0005)	0.0019*** (–0.0005)
Poor village	–0.0315* (–0.0171)	–0.0325* (–0.0171)	–0.0273 (–0.0171)
Village is located in eastern China	–0.0300* (–0.0175)	–0.0299* (–0.0175)	–0.0374** (–0.0176)
Village is located in central China	0.0696*** (–0.0198)	0.0709*** (–0.0198)	0.0636*** (–0.0199)
Sample size	3 295	3 295	3 295
Log likelihood	–1 732.5532	–1 731.0077	–1 730.5530
LR χ^2 (18)	183.0200	186.1100	187.0200
Probability > χ^2	0	0	0
Pseudo R^2	0.0502	0.0510	0.0513

***, **, * $P < 0.001$, $P < 0.01$, and $P < 0.05$, respectively; LR – likelihood ratio

Source: Authors' own elaboration based on data from China Rural Revitalization Survey (CRRS; http://rdi.cass.cn/ggl/202210/t20221024_5551642.shtml)

to correct for potential endogeneity problems. Table 3 displays the results of the Ivprobit regression model. The findings indicate that, with the inclusion of the instrumental variable 'village broadband household penetration rate' in the model, Internet access, smartphone Internet access, and computer Internet access all significantly impacted the willingness of households to join farmer professional cooperatives. Moreover, the impact direction was consistent with the probit baseline regression. This outcome robustly confirmed the potential influence of Internet access on households' willingness to join farmer professional cooperatives.

Heterogeneity analysis. Through meticulous heterogeneity analysis of samples with different characteristics, a more comprehensive understanding of the impact of Internet access on farmers' participation in farmer professional cooperatives can be obtained. This in-depth exploration contributed to a more accurate grasp of the role of Internet access in farmers' participation in farmer professional cooperatives. Therefore, this study started with individual characteristics, including age, education level, cadre status, and other demographic features, to comprehensively present the heterogeneous impact of Internet access on farmers' participation in farmer professional cooperatives.

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Table 3. Benchmark regression results for model estimation of the effect of Internet access on farmers' willingness to participate in farmer professional cooperatives (Ivprobit regression)

Variable	Participation in farmer professional cooperatives		
	Internet access	Accessing the Internet with a smartphone	Internet access using a computer
Internet access	3.8860*** (–0.5360)	–	–
Accessing the Internet with a smartphone	–	3.5010*** (–0.5230)	–
Internet access using a computer	–	–	1.3100* (–0.6880)
Control variables	yes	yes	yes
Sample size	3 295	3 295	3 295
Log likelihood	–1 809.6461	–2 132.9969	–3 564.8093
Wald χ^2 (18)	2 215.7700	1 987.5600	268.9400
Probability > χ^2	0	0	0

***, **, * $P < 0.001$, $P < 0.01$, and $P < 0.05$, respectively

Source: Authors' own elaboration based on data from China Rural Revitalization Survey (CRRS; http://rdi.cass.cn/ggl/202210/t20221024_5551642.shtml)

Table 4. Impact of Internet access on farmers' participation in professional cooperatives: A heterogeneity analysis

Variable	Participation in farmer professional cooperatives					
	age > 60 years old	age < 60 years old	junior high school and above	below junior high school	cadre status	non-cadre status
Internet access	0.0705** (–0.0335)	0.0790 (–0.0803)	0.0822 (–0.0567)	0.0910** (–0.0388)	0.1940 (–0.1370)	0.0686** (–0.0326)
Control variable	yes	yes	yes	yes	yes	yes
Sample size	1 154	2 141	2 009	1 286	610	2 685
Log likelihood	–550.3202	–1 172.7081	–1 098.8143	–624.6272	–384.2400	–1 334.7262
LR χ^2 (17)	40.8500	139.9400	128.9600	56.4100	22.0200	142.9900
Probability > χ^2	0.0010	0.0000	0.0000	0.0000	0.1839	0.0000
Pseudo R^2	0.0358	0.0563	0.0554	0.0432	0.0279	0.0508

***, **, * $P < 0.001$, $P < 0.01$, and $P < 0.05$, respectively; LR – likelihood ratio

Source: Authors' own elaboration based on data from China Rural Revitalization Survey (CRRS; http://rdi.cass.cn/ggl/202210/t20221024_5551642.shtml)

Table 4 shows the results of heterogeneity analysis in this study. Specifically, concerning the heterogeneity at the age, the impact of Internet access on farmers aged 60 and above was significant ($P < 0.01$), while the impact on farmers below 60 was not significant. The heterogeneity analysis of education level indicate that Internet access significantly affected farmers with an education level below junior high school ($P < 0.01$), while the impact on farmers with an education level of junior high school or above was not significant. Regarding the heterogeneity in cadre status, the study found that the impact of Internet access on farmers without cadre status was significant ($P < 0.01$), while the impact on farmers with cadre status was not significant.

DISCUSSION

As shown in Table 2 and Table 3, both the probit regression model and the Ivprobit regression model collectively reveal the impact of Internet access on farmers' willingness to join farmer professional cooperatives. Despite previous research confirming the influence of information acquisition on public willingness to join, these studies have predominantly focused on the content of information acquisition, such as the benefits and risks of farmer professional cooperatives, with insufficient attention devoted to the avenues through which farmers access information (Lei et al. 2022; Yue et al. 2023). According to the theory

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of media as information mentioned in the communication theory, the introduction of the Internet may play a crucial role in farmers' information acquisition (Garrett 2020; Zhuravskaya et al. 2020). Compared to traditional media, the Internet, as an emerging information dissemination channel, provides farmers with more diverse and timely sources of information, which enables them to obtain information about farmer professional cooperatives more flexibly, including industry dynamics, success stories, advanced technologies, and market trends, thereby enables them to comprehensively evaluate the pros and cons of joining (Zhang et al. 2020; Ndimbwa et al. 2021). Meanwhile, in China's rural areas, the Internet information structure has developed to a relatively advanced level, and farmers now have easy access to Internet information within China, which has greatly enhanced their ability to access key information such as agricultural technologies, market information and environmental protection strategies (Zhang et al. 2016). Therefore, this study not only expanded the theoretical understanding of the scope of the Internet access impact but also emphasised the Internet as an essential channel for information acquisition and social interaction, exerting an indispensable influence on shaping individual attitudes of farmers.

The heterogeneity analysis based on age revealed that Internet access significantly influenced the willingness of farmers aged 60 and above to participate in farmer professional cooperatives, while its impact on farmers below 60 was not significant. This observation can be attributed to the increased labour difficulties faced by older farmers in agricultural production. As the age of farmers above 60 increases, their physical strength and skills for engaging in agricultural production may gradually decline, leading to decreased production efficiency under traditional agricultural models (Peters et al. 2008; McPhee et al. 2016). Through Internet, they can more timely access information related to market demands, new technologies, and modern agricultural management methods, enabling them to adjust production strategies and enhance agricultural efficiency (Kukreja and Chakrabarti 2013; Getahun 2020). Second, because many older farmers lack the necessary technical knowledge and experience, they often need to rely on the help of their children or community members to use the Internet (Ma et al. 2020). This implies that their ability to access new information is significantly enhanced when Internet access is available, as they previously lacked efficient means of obtaining information. Consequently, Internet access has a greater impact on older farmers, particularly in terms

of accessing information about specialised farmers' cooperatives and increasing their willingness to join these cooperatives (Weng et al. 2023). In contrast, younger farmers are already relatively proficient in obtaining relevant information through the Internet, and thus, the impact of Internet access on their membership in specialised farmers' cooperatives is not as significant. The convenience of the Internet helps compensate for the lack of traditional agricultural knowledge and information acquisition for older farmers, improving their agricultural economic returns and thereby increasing their probability of participating in farmer professional cooperatives (Gao et al. 2020).

In the heterogeneity analysis based on education level, the research findings indicated that Internet access significantly influenced the participation of households with an education level below junior high school in farmer professional cooperatives compared to households with at least a junior high school. This result highlighted the potential role of the Internet in alleviating social information inequality arising from differences in education levels (DiMaggio et al. 2001; Chigona et al. 2009). Households with an education level below junior high school often face challenges in information acquisition, and Internet access provides them with a pathway to bridge the information gap (Alpay et al. 2009). Through Internet access, lower-educated groups find it easier to obtain information related to farmer professional cooperatives, thereby expanding their understanding of cooperative operation mechanisms, which contributes to stimulating their motivation for more active participation in farmer professional cooperatives (Huxhold et al. 2020; Helsper 2021). Therefore, Internet access is not merely a tool for information acquisition; it is also a medium that promotes social equality and sustainable development, especially among rural residents with lower education levels (Parkinson and Lauzon 2008; Wang et al. 2022). This finding underscores the importance of promoting technology diffusion and equal access to information opportunities in advancing rural community development.

In particular, the impact of Internet access on farmers without administrative status was more significant in terms of their participation in farmer professional cooperatives. This phenomenon may be attributed to two main factors. On the one hand, farmers with administrative status typically possess greater advantages in social networks and resources (Mekonnen et al. 2018). They may have broader and closer social connections through their positions or social status, including contacts with governmental institutions,

industry professionals, and fellow farmers (Lin 1999). Even without Internet access, they can obtain the necessary information through traditional social networks and official channels, making the impact of Internet access on their decision-making relatively minor. On the other hand, the Internet, as an open platform, provides farmers without administrative status with more equal opportunities for information participation. In contrast to traditional social networks, information on the Internet is more decentralised, allowing each individual to access information equally, irrespective of social status (Datta et al. 2010; Musiał and Kazienko 2013). This eliminates the constraints of traditional social hierarchies on information access for farmers without administrative status, enabling them to actively circulate and share information related to farmer professional cooperatives. This equalisation of information access opportunities contributes to enhancing their awareness and understanding of farmer professional cooperatives, strengthening their willingness to participate in these social organisations (Kumar et al. 2015).

Management implication. Based on the significant impact of Internet access on the willingness of farmers to join farmer professional cooperatives as described above, this study proposes the following management implications to better leverage the positive role of the Internet in enhancing the organisational level of farmers' production and management, driving comprehensive rural revitalisation, and achieving rural modernisation.

The primary strategy is to strengthen the construction of rural information infrastructure.

Although Internet coverage in rural China has already achieved comprehensive coverage and 5G networks have reached most township-level areas, facilitating Internet access for farmers, further efforts are still needed to accelerate rural Internet access and reduce costs (Ma et al. 2020). These efforts aim to eliminate barriers to Internet usage among farmers and create a favourable external environment for their full integration into the networked society (Ma 2024). This strategy not only helps to bridge the information gap between urban and rural areas but also promotes the development of digital agriculture, enhancing the efficiency and quality of agricultural production (Qu et al. 2018). Furthermore, the widespread adoption of the Internet allows farmers to participate in broader social networks, expand social relationships, increase cooperation partners, and promote information sharing and technological cooperation, which promote the integration and development of rural communities, creating a more cohesive social network (Oreszczyn et al. 2010).

Secondly, to more effectively address the heterogeneous effects of Internet access on farmers' participation in farmer professional cooperatives, targeted assistance and relevant training for farmers' Internet access and use should be strengthened. Special attention needs to be given to the Internet situation of older farmers, those with lower educational levels, and non-cadre individuals. Through targeted training and support, the level of Internet access and usage efficiency of these farmers can be steadily improved, thereby effectively mitigating the problem of social resource inequality among farmers. Implementing this strategy will ensure the inclusiveness of rural Internet development, enabling more farmers to fully enjoy the conveniences and opportunities brought by the Internet. By providing customised assistance and training for specific groups, governments and related organisations can better achieve equitable distribution of social resources and promote a more equal and comprehensive development of the Internet in rural areas.

CONCLUSION

In light of the critical role of Internet access in the dissemination of information, this paper presents an empirical study that reveals that Internet access can significantly impact the willingness of farmers to participate in farmer professional cooperatives. The results provide substantial support for the application of digital technology in rural communities and are of great importance in promoting sustainable rural economic development and enhancing farmers' income. The main conclusions are as follows:

Internet access significantly influences the willingness of farmers to participate in farmer professional cooperatives.

The positive impact of Internet access is significant for farmers over the age of 60 in their willingness to join farmer professional cooperatives; it is also significant for farmers with junior high school education or below, and for those without cadre status.

This study solely utilises data from rural areas in China, which limits the cross-validation of the main findings in other socio-economic environments. Therefore, the broader applicability of the results requires further validation.

Another limitation of this study is that it failed to fully explore the complex motivations that affect farmers' use of the Internet, including potential motivations, the quality and practicality of Internet information, etc.

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Future research will provide a deeper perspective for a comprehensive understanding of farmers' behaviour by introducing interdisciplinary theories and methods such as psychology and sociology.

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