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Study on the Impact of Internet Usage, Aging on Farm Household Income

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Abstract: Increasing farmers' incomes and empowering rural revitalization through the digital economy are important issues of widespread concern in our society today. From the perspective of aging, this paper uses the 2016, 2018, and 2020 China Family Panel Studies (CFPS) data to examine the impact of Internet usage on farm household income in the realistic context of the severe aging situation in rural areas, to explore the specific mechanisms through which aging plays a role. A further comparative analysis of the heterogeneity of Internet usage and aging effects on different sources of farm household income is performed. The study finds that Internet use by farmers increases household income, but aging diminishes the boosting effect of Internet usage on household income. By reducing off-farm employment and increasing family care, aging reduces the Internet's boosting effect on farm household income. Among household income sources, Internet usage significantly contributes to the growth of farm household wage income. Aging dampens the growth of all income sources except transfer income. Aging enhances the boosting effect of Internet usage on the transfer income of farm households; however, it weakens its boosting effect on the wage income of farm households. Therefore, there is an urgent need to promote the construction of rural digital infrastructure, improve farmers' digital literacy, and improve rural pension infrastructure and services, to escort the digital transformation of agriculture and rural areas and the common prosperity of farmers.

Keywords: internet usage; aging; farm household income; off-farm employment; family care



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1. Introduction

In the era of digital transformation, digital technology, represented by the Internet, has reached rural areas in China. The Internet penetration rate in rural areas of China is 57.6% as of December 2021. All administrative villages have gained “broadband village access”, and there are 284 million (The data information comes from the 49th “Statistical Report on Internet Development in China” released by China Internet Network Information Center (CNNIC)) Internet users in rural areas. As a result of Internet usage, farmers have access to a vast amount of information resources, which will influence not only the adoption of agricultural technologies [1], land transfers [2,3], off-farm employment [4], and other resource allocation decisions. Additionally, farm household income [5], consumption [6], and well-being [7] will be impacted, creating new challenges and opportunities for agricultural production and farm household life. With the penetration of Internet information technology in rural areas, promoting the digital construction of agriculture and improving farmers' digital literacy has become an important means of achieving modernization and prosperity in rural areas.

There is a wealth of existing research on the Internet and farm household income, but no consistent conclusions have been reached. A large number of studies have concluded

that Internet usage increases farm household income. Ma found that Internet usage could increase household income significantly, using a sample of rural households from China [8]. Siaw found that internet usage increased farm income and household income by 20.1% and 15.47%, respectively, using survey data from 478 rural farmers in two regions of Ghana [9]. Xie further demonstrated that Internet usage was more effective in reducing poverty for full-time farmers than for part-time and non-farmers [10]. Scholars have further explored the specific paths through which farmers use the Internet to increase their income, finding that Internet usage could affect farm household income mainly by raising the selling price of agricultural products [11], increasing total factor productivity [12], promoting off-farm employment [13], and pulling entrepreneurship [13].

A review of the literature reveals that existing studies about the impact of Internet usage on farm household income have ignored the realistic context of aging in rural areas. According to the China Rural Revitalization Survey in 2021, 20.04% of the population aged 60 and above and 13.82% of the population aged 65 and above live in rural areas, and the degree of aging in rural areas far exceeds the national average, which has fully reached the standard of “aging society”. Does aging present opportunities or challenges for rural economies? With the deepening of the rural elderly population, the poverty headcount ratios of most rural areas increase year by year [14]. However, modern agricultural technologies and organization methods have reduced the constraints of physical and human capital on agricultural production, so there is no need to be too pessimistic about rural aging [15]. Thus, it is evident that existing studies that do not take into account the reality of aging in rural areas will be biased. The aging population is faced with “digital inclusion” difficulties as a result of digitalization, which are exacerbated by the lack of human capital in rural areas [16]. How does aging affect the impact of Internet usage on farm household income? This will be the focus of this paper. To this end, this paper addresses the gaps in the existing research by examining the impact of Internet usage on farm household income from the perspective of aging, using data from the 2016, 2018, and 2020 China Family Panel Studies (CFPS).

Possible innovations are as follows. First, the existing literature on the Internet and farm household income largely ignores the influence of aging. Taking into account the severe aging situation in rural areas, this paper expands the existing research perspective by including aging in the examination of the income-boosting effects of Internet usage in rural areas and explores the role that aging plays in determining the impact of Internet usage on farm household income at the micro household level. Second, this paper does not limit itself to revealing the moderating role played by aging in the income-boosting effect of Internet usage but goes deeper into analyzing the specific mechanisms of aging that affect the income-boosting effect of farmers’ Internet usage, providing evidence to support the non-farm transfer of surplus rural labor and improve the rural social pension system. Finally, this paper distinguishes different sources of farm household income and further characterizes the heterogeneity of the moderating effects of Internet usage and aging on income. This provides a reference for the government to formulate targeted policies to make the most of the income-boosting effects of the Internet and the positive moderating effects of aging, which will broaden farm household income channels.

The chapters of this paper are organized as follows. Part II is the theoretical analysis. Part III is the research design. Part IV is the empirical analysis. Finally, there are conclusions and recommendations.

2. Theoretical Analysis

2.1. Impact of Internet Usage on Farm Household Income

According to information search theory, farmers are constrained by the cost of searching for information. Taking into account the higher search costs, farmers are forced to make resource allocation decisions based on limited information. As a result of the emergence of the Internet, information has been transmitted in a new manner, overtaking the traditional way of transmitting and receiving information, breaking time and distance barriers, and

thus can effectively reduce the cost of searching for information [17]. With the continuous improvement of network infrastructure in rural areas, farmers can receive all the information they need through the Internet, which allows them to relax their information constraints and make optimal decisions to maximize their household's wealth.

There are four main sources of farm household income: wage income, business income, property income, and transfer income. So how does Internet usage affect farm household income? First, a key to raising farmers' income is guiding the transfer of surplus rural labor to non-farm sectors [18]. Rural areas have popularized the Internet, breaking the urban–rural border. Farmers' Internet usage can not only establish a broader range of social networks and access employment information and channels [19] but also acquire health information, upgrade their skills [20], and accumulate skills-based and health-care human capital, thus, making it easier to obtain non-farm employment and increase household income [21]. Second, Internet usage affects agricultural business income from both production and marketing aspects. As far as production is concerned, farmers use the Internet to learn more accurate and timely information regarding market demand and make more profitable decisions [22]. In terms of marketing, the Internet can provide farmers with timely and accurate market price information to help them seize arbitrage opportunities and improve their bargaining power, thereby increasing the selling price of agricultural products and improving their family's farm business income [23]. Additionally, the Internet helps farmers increase their non-farm business income. Using the Internet, farmers can access information and expand their social networks at low cost [24] and identify entrepreneurial opportunities with accuracy [25]. Moreover, the network environment promotes the growth of microfinance, eases credit constraints for entrepreneurial farmers, and helps farmers access markets, thus, promoting entrepreneurship among farmers and improving their non-farm business income. Thirdly, with the popularity of the Internet in rural areas, it can serve as a means to educate farmers about and involve them in the financial market, thereby reducing the possibility of financial exclusion [3] and broadening the sources of household income. Finally, farmers are able to gain a better understanding of relevant government subsidies, concessions, and funding policies through the Internet and make declarations in accordance with their actual circumstances, thereby increasing their household transfer incomes.

Hypothesis 1 (H1). *Internet usage has a significant positive effect on farm household income.*

2.2. The Moderating Role of Aging in the Impact of Internet Usage on Farm Household Income

China has entered a stage of rapid aging, and population aging in rural areas is becoming more serious (The China Rural Revitalization Survey of 2021 indicates that the proportion of rural residents aged 60 and over has reached 20.04%, and the proportion of rural residents aged 65 and over has reached 13.82%. As a result, rural areas are aging faster than other parts of the country). Consequently, the availability of young and strong rural labor is reduced, which affects farm household income. On the one hand, the length and intensity of labor [26], cognitive level [27], and learning ability [28] of the elderly labor force are in a disadvantageous position compared with the young and strong labor force. Furthermore, their ability to accept and apply new technologies is less [29], which leads to lower labor productivity and impacts the boosting effect of the farm household income. On the other hand, rural laborers who move to non-farm industries are generally engaged in heavy physical and light-skilled jobs with high health requirements, and enterprises prefer young and strong laborers, while older laborers receive relatively fewer non-farm employment opportunities, which is not conducive to the growth of the farm households' wage income. Due to China's improved social security system, the aging rural population not only receives a pension but most provinces also pay an old-age allowance, increasing the transfer income of aging households. Despite this, pensions and old age allowances are only intended to provide a basic living standard for the aging population and are far

below the income of the young and active population. When considered together, aging negatively impacts the farm household income.

Hypothesis 2 (H2). *Aging has a significant negative effect on farm household income.*

As discussed earlier, the farmers' Internet usage can relax information constraints and increase household income. However, the reality of the serious aging situation in rural areas cannot be ignored, and the aging population and proportion in China will continue to rise until the middle of this century [30], making the digital transformation of agriculture and rural areas a major challenge. The increasing aging of the rural population may negatively impact labor supply and Internet usage. On the one hand, the aging rural workforce is forced to reduce labor supply length and intensity due to their physical condition. On the other hand, due to the generally lower human capital and weaker digital literacy of the aging rural labor force, the Internet has failed to play a full role in increasing income. In summary, the Internet theoretically facilitates increased household income by relaxing farmers' information constraints. The boosting effect of Internet usage will, however, diminish with age.

Next, this paper explores how aging affects the income-boosting effects of Internet usage from the perspectives of non-farm employment and family care. In terms of non-farm employment, Internet usage is great for rural households. However, the older rural population is generally less educated and does not have the skills to search and apply for jobs, which, combined with their physical quality and "local" sentiment, makes it hard for them to work outside the farm. This, in turn, affects the farm household income. From the perspective of family care, the elderly population gradually loses its resistance as they age, making them more susceptible to various diseases and requiring daily assistance. However, the elderly services system in rural areas is not perfect and is dominated by family-center care [31] due to the lack of related infrastructure and service institutions. It should not be overlooked that children's caregiving behavior has a "punitive effect" on their productive work, i.e., the caregiver's labor force participation rate decreases [32], the hours of labor supply decrease [33], and labor income decreases [34]. Consequently, once an elderly person becomes disabled in a rural household, they will require family care from their children. This will affect the children's productive work and off-farm employment, which, in turn, affects their household income.

Hypothesis 3 (H3). *Aging will diminish the effect of Internet usage on boosting farm household income.*

Hypothesis 4 (H4). *Aging negatively affects farm household income by reducing off-farm employment and increasing family care.*

3. Research Design

3.1. Data Source

This paper is based on the data collected during three rounds of the China Family Panel Studies (CFPS) in 2016, 2018, and 2020. The CFPS survey sample covers 25 provinces (municipalities/autonomous regions) and tracks data collected at the individual, household, and community levels. The survey population includes all household members and is a nationally representative sample. This paper investigates the impact of Internet usage on farm household income in the context of aging. Considering that the minimum measure of aging and the impact of Internet usage are at the household level, we choose to research on a household basis. In this paper, by combining and matching the household, individual, and community samples in the three rounds of the survey, we finally obtain 15,939 households in rural areas. Since no survey about the head of household exists in CFPS, this paper draws upon existing studies and considers the financial respondent as the head of household. In addition, all household variables use the mean values of household members.

3.2. Variable Description

Farm household income is the explained variable in this paper, and it is defined according to the question “total net household income”. To reduce heteroskedasticity caused by a large income gap, this paper uses the logarithm of farmers’ household income as the farm household income. The robustness test section uses the share of farm household agricultural income as the explained variable since there are more sources of farm household income and there may be measurement error.

The core explanatory variable in this paper is Internet usage, which is defined by the questions “mobile access or not” and “computer access or not”. If both questions are answered no, the farmer is considered not to be using the Internet and the value is 0. Otherwise, the farmer uses the Internet and takes 1. We refer to Yang’s approach of using household head Internet usage as a proxy variable for household Internet usage [35].

Farm household income is affected by a variety of factors. This paper introduces head of household and household characteristics variables based on the existing literature to make sure the model setting is sound and the research results are reliable. The estimation bias is reduced by controlling for area effects and time effects. The head of household characteristics include age, gender, household registration type, health status, and education level. The variables of household characteristics include family size, land, number of farm workers, migrant workers, entrepreneurship, and agricultural investment. Table 1 reports the variables’ definitions and descriptive statistical characteristics.

3.3. Model Setting

This paper constructs panel data using the 2016, 2018, and 2020 CFPS data to analyze the impact of Internet usage on farm household income with the following fixed effects model settings.

$$\ln(Y_{it}) = \beta_0 + \beta_1 NET_{it} + \beta_2 X_{it} + \theta_i + \delta_t + \varepsilon_{it} \quad (1)$$

In Equation (1), Y_{it} represents the total household income of farm households i in year t . NET_{it} is the core explanatory variable, representing whether farm household i uses the Internet in year t . X_{it} represents a series of control variables affecting farm household income. θ_i represents household-fixed effects. δ_t represents year-fixed effects, and ε_{it} is a disturbance term that follows a standard normal distribution.

Additionally, this paper develops an interaction term joining the model of Internet usage and aging to examine how Internet usage affects farm household income in the current setting of the increasingly severe population aging in rural areas:

$$\ln(Y_{it}) = \beta_0 + \beta_1 NET_{it} + \beta_2 OLD_{it} + \beta_3 NET_{it} \times OLD_{it} + \beta_4 X_{it} + \theta_i + \delta_t + \varepsilon_{it} \quad (2)$$

In Equation (2), OLD_{it} refers to the household aging rate of farm households i in year t , as measured by the proportion of the household’s population aged 60 and above. The interaction term $NET_{it} \times OLD_{it}$ is used to examine the moderating role that aging plays in the impact of Internet usage on farm household income.

Table 1. Report on the variables' definitions and descriptive statistical characteristics.

Variable Name	Meaning	Mean	SD	Freq.	Perc. %	Median	IQR
Farm household income	The logarithm of net household income	10.475	1.138				
Internet usage	Take 1 for any mobile or computer access, take 0 for otherwise						
	yes			5698	35.75		
	no			10,241	64.25		
Age	Age of head of household (years old)	51.783	14.307				
Gender	Gender of the head of household: male = 1, female = 0						
	male			8862	55.60		
	female			7077	44.40		
Household registration type	Household Registration: agricultural = 1, non-agricultural = 0						
	agricultural registration			14,903	93.50		
	non-agricultural registration			1036	6.50		
Health status	There are five levels, of which 1 is unhealthy and 5 is very healthy					3	2
	unhealthy			3288	20.63		
	average			2532	15.89		
	fairly healthy			5834	36.60		
	healthy			2238	14.04		
	very healthy			2047	12.84		
Education level	Years of education of the head of household (years)	6.132	4.378				
Family size	Number of family members (persons)	4.008	2.022				
Land	Whether the household has arable land						
	yes			8010	50.25		
	no			7929	49.75		
Number of farmers	Number of people engaged in agricultural production in households (persons)	1.480	1.301				
Number of migrant workers	Number of people in the household who work outside the home (persons)	0.757	0.983				
Entrepreneurship	Whether anyone in the household is self-employed						
	yes			1193	7.48		
	no			14,746	92.52		
Agricultural investment	The number of agricultural production inputs is taken as a logarithm (yuan)	5.943	3.970				

4. Empirical Analysis

4.1. Baseline Regression Results and Analysis

This paper examines the impact of Internet usage on farm household income by gradually introducing control variables. The baseline regressions of how Internet usage affects farm household income are shown in Table 2, with all regressions including household-fixed and year-fixed effects. Columns (1)–(3) in Table 2 report the results for introducing only core explanatory variables, core explanatory variables and personal characteristics of farmers, and all control variables, respectively. The R^2 of the equation gradually rises, indicating that the model's fit improves with the gradual addition of control variables.

Table 2. Baseline regression results for the impact of Internet usage on farm household income.

Variable Name	(1)	(2)	(3)
Internet usage	0.581 *** (0.018)	0.140 *** (0.024)	0.146 *** (0.022)
Age		−0.017 *** (0.001)	−0.011 *** (0.001)
Gender		−0.013 (0.020)	0.024 (0.018)
Household registration		−0.430 *** (0.036)	−0.487 *** (0.034)
Health status		0.041 *** (0.008)	0.032 *** (0.007)
Education level		0.040 *** (0.003)	0.032 *** (0.002)
Family size			0.143 *** (0.005)
Land			0.048 (0.046)
Agricultural investment			0.000 *** (0.000)
Number of farmers			0.002 (0.008)
Number of migrant workers			0.268 *** (0.009)
Entrepreneurship			0.531 *** (0.030)
Constant	10.311 *** (0.121)	11.549 *** (0.137)	10.454 *** (0.107)
N	15,939	15,939	15,939
R^2	0.374	0.466	0.642
Household-fixed effect	Yes	Yes	Yes
Year-fixed effect	Yes	Yes	Yes

Note: *** indicates significance at the 1% level, and values in parentheses are robust standard errors. The same applies to the table below.

All other things being equal, the regression findings in column (3) of Table 2 show that at the 1% level, Internet usage has a considerable positive influence on farm household income, supporting Hypothesis 1. This finding is consistent with the analysis in the theoretical section, which shows that the Internet relaxes farmers' information constraints and facilitates their optimal decision-making and, thus, increases household income.

Control variables such as the age of the household head and the type of agricultural household registration have a significant negative effect on farm household income. Rural households with elderly heads of household have lower human capital and are less receptive to new things, which makes it difficult to guide the household to higher income levels. Human capital, consisting of health status and education level, can significantly enhance farm household income. Family size and number of migrant workers significantly and positively affect farm household income, showing that the off-farm employment of

rural laborers for wage income is an essential strategy to increase household income. In addition, entrepreneurial behavior contributes to increasing the farm household income. Investment in agricultural production has a significant positive effect on household income, but the effect is small, most likely due to the time lag in the role of agricultural investment, which does not have a significant effect on farm household income during the current investment period.

4.2. Robustness Tests

4.2.1. Endogeneity Discussion

The previous paper empirically tests the positive effect of Internet usage on farm household income but does not take into account the existence of self-selection problems in the core explanatory variable Internet usage and the two-way causality between Internet usage and farm household income [36], which may lead to biased estimates of the results. According to Zhou, Cui [13], “average Internet usage in farmers’ villages” is chosen as an instrumental variable for whether farmers use the Internet or not. From the perspective of the relevance of the instrumental variables selected, village Internet usage will, to some extent, influence farmers’ Internet use decisions due to the effect of herd mentality. From an exogenous perspective, village Internet usage does not have a direct effect on the household income of a specific farm household. Thus, theoretical village Internet usage satisfies the instrumental variables.

Table 3 reports the results of the two-stage least squares regression with the average Internet usage in the selected villages as the instrumental variable. The results in column (1) of Table 3 show that the F-statistic of the first stage joint test is 724.210 and the Cragg–Donald Wald F-statistic of the weak instrumental variable test is 1376.544, which is greater than the critical value of 8.96 under 15% bias, so the original hypothesis of “weak instrumental variable” can be rejected. In addition, village Internet usage has a positive effect on farm household Internet usage at the 1% significance level, indicating corroboration of the relevance of the instrumental variables.

Table 3. Two-stage least squares regression results.

Variable Name	(1) First Stage: Internet Usage	(2) Second Stage: Farm Household Income
Internet usage	—	0.576 *** (0.072)
Village Internet usage	0.643 *** (0.017)	—
Head of household characteristic variables	Yes	Yes
Household characteristics variables	Yes	Yes
Constant	0.746 *** (0.026)	9.774 *** (0.101)
N	15,939	15,939
R ²	0.736	0.631
F-statistic value	724.210 ***	—
Chi-square	—	5802.840 ***
Household-fixed effect	Yes	Yes
Year-fixed effect	Yes	Yes

Note: *** indicates significance at the 1% level, and values in parentheses are robust standard errors.

The next topic covered is the exogeneity of instrumental variables. The Hansen J statistic of 0 indicates that the model is precisely identified and the exogeneity of the instrumental variables cannot be tested, but the instrumental variables also need to be tested for exclusivity, i.e., to verify that the instrumental variables affect the explanatory variables through the only path of the explanatory variables. Table 4 reports the results

of the exclusion test for the instrumental variables, where the results in column (1) show that the instrumental variable village Internet usage has a significant positive effect on farm household income at the 1% level, and column (2) shows that the effect of the instrumental variable village Internet usage on farm household income is no longer significant after the inclusion of Internet usage, indicating that the instrumental variable passes the exclusion test.

Table 4. Results of the instrumental variable exclusivity test.

Variable Name	(1)	(2)
Internet usage	—	0.147 *** (0.022)
Village Internet use	0.278 *** (0.048)	0.000 (0.053)
Head of household characteristic variables	Yes	Yes
Household characteristic variables	Yes	Yes
Constant	10.739 *** (0.213)	10.455 *** (0.108)
N	15,939	15,939
R ²	0.641	0.690
Household-fixed effect	Yes	Yes
Year-fixed effect	Yes	Yes

Note: *** indicates significance at the 1% level, and values in parentheses are robust standard errors.

In summary, the instrumental variables pass the tests of correlation and exogeneity, indicating that the selection of village Internet usage as an instrumental variable for farmers' Internet usage is appropriate. As can be seen in column (2) of Table 4, Internet usage has a significant positive effect on farm household income at the 1% level. This indicates that Internet usage still has a significant positive effect on farm household income after accounting for endogeneity issues, demonstrating the robustness of the baseline regression estimation results.

4.2.2. Robustness Tests

- (1) Replacement of the explained variables. Theoretically, using the Internet has an impact on how farm household labor resources are allocated by easing informational constraints, which makes it easier to transfer excess rural labor to non-farm industries and increases wage income, i.e., Internet usage lowers the share of agricultural income in household income. This paper changes the explained variable “annual household income” to “agricultural income as a share of household income”, and it is predicted that Internet usage will have a negative impact on the farm household share of the agricultural income.
- (2) Replacement of the core explanatory variables. This paper specifically replaces “whether farmers use the Internet” with “hours of Internet access per week” and “the importance of the Internet as an information access channel for farmers (1 means very unimportant, 5 means very important)”. Compared with farmers' Internet usage, the weekly length of Internet access is more indicative of the depth of farmers' Internet usage, and the longer the length of farmers' Internet usage, the stronger their ability to use the Internet. Additionally, to some extent, their Internet usage behavior is reflected in how important they view the Internet as a medium for accessing information. In addition, we refer to Zhou and Yang [37] to construct an indicator of the Internet activity level based on the questions related to the purpose and frequency of Internet usage among farmers, i.e., the existence of usage purpose is multiplied by the frequency of usage for the corresponding purpose. According to the questionnaire setup, the five purposes of Internet usage include study, work, socialization, entertainment, and business activities, and the frequency of usage is assigned as 0–6 from low to high.

- (3) Propensity score matching method. To further avoid the estimation bias caused by the sample self-selection problem, this paper uses the propensity score matching method to estimate the impact of Internet usage on farm household income again. The specific steps are as follows. ① Farmers using the Internet are used as the experimental group, and farmers not using the Internet are used as the control group, and all control variables are selected as variables for matching. ② The propensity scores are estimated by using the logit model. ③ Choose three methods for matching, namely, nearest neighbor matching, radius matching, and kernel matching, respectively. The equilibrium test results show that all matching methods presented in this paper are logical and satisfy the equilibrium hypothesis.

Table 5 reports the regression results of the robustness test. Columns (1)–(4) show the results of robustness tests for the replacement variables, where the results in column (1) show a significant negative effect of Internet usage on the share of the farm income in farm households, which is consistent with the expected results. It can be seen from columns (2)–(4) that the length of Internet access, the importance of the Internet, and the Internet activity level have a significant positive effect on farm household income at the 1% level, indicating the robustness of the baseline regression results. Columns (5)–(7) show the regression results of Internet usage affecting farm household income under three different matching methods, whether nearest neighbor matching, radius matching, or kernel matching, the matched regression results indicate that Internet usage positively affects farm household income at the 1% significance level. This result is consistent with the baseline regression results, again demonstrating the robustness of the estimation results.

Table 5. Robustness test regression results.

Variable Name	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Replace Variables				PSM		
	Share of Farm Income	Farm Household Income	Farm Household Income	Farm Household Income	Nearest Neighbor Matching	Radius Matching	Kernel Matching
Internet usage	−0.040 ** (0.018)	— —	— —	— —	0.234 *** (0.031)	0.241 *** (0.032)	0.163 *** (0.022)
Length of Internet access	— —	0.004 *** (0.001)	— —	— —	— —	— —	— —
Importance of the Internet	— —	— —	0.039 *** (0.007)	— —	— —	— —	— —
Internet activity level	— —	— —	— —	0.019 *** (0.002)	— —	— —	— —
Head of household characteristic variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Household characteristic variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	0.279 *** (0.061)	10.340 *** (0.196)	10.456 *** (0.107)	10.711 *** (0.220)	9.871 *** (0.238)	9.533 *** (0.450)	10.369 *** (0.110)
N	15,939	15,939	15,939	15,939	15,939	15,939	15,939
R2	0.606	0.625	0.642	0.662	0.611	0.618	0.630
Household-fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year-fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Note: ** and *** indicate significance at the 5% and 1% levels, respectively, and values in parentheses are robust standard errors.

4.3. The Moderating Effect of Aging on the Income-Boosting Effects of the Internet Usage

In the previous paper, the empirical results, after considering possible endogeneity issues and a series of robustness tests, still show a significant positive effect of Internet usage on farm household income but do not take into account the realistic context of the severe aging situation in rural areas. To this end, this section uses the number of persons aged 60 years and older as a proportion of the total number of persons in households to characterize the level of aging, based on internationally accepted standards of population aging and aging-related studies.

Table 6 reports the regression results of Internet usage and aging affecting farm household income. It can be observed from columns (1) and (2) that aging has a significant negative impact on farm household income regardless of whether the head of household and household characteristics are controlled. This indicates that higher household aging decreases the household labor supply and increases the burden of supporting the elderly, which ultimately leads to lower household income levels, and hypothesis 2 is confirmed. Column (3) incorporates an interaction term between Internet usage and aging to examine the role that aging plays in the income-boosting effects of Internet usage. After adding the interaction term, the coefficient of Internet usage decreases from 0.180 to 0.138. The interaction term significantly and negatively affects household income at the 1% level, which indicates that aging significantly weakens the income-boosting effects of Internet usage, thereby supporting hypothesis 3.

Table 6. Regression results of Internet usage and aging affecting farm household income.

Variable Name	(1)	(2)	(3)
Internet usage	0.333 *** (0.018)	0.180 *** (0.021)	0.138 *** (0.022)
Aging	−1.254 *** (0.027)	−0.603 *** (0.034)	−0.649 *** (0.035)
Internet usage × Aging			−0.565 *** (0.084)
Head of household characteristic variables	No	Yes	Yes
Household characteristic variables	No	Yes	Yes
Constant	10.813 *** (0.091)	10.360 *** (0.103)	10.386 *** (0.103)
N	15,939	15,939	15,939
R ²	0.602	0.741	0.743
Household-fixed effect	Yes	Yes	Yes
Year-fixed effect	Yes	Yes	Yes

Note: *** indicates significance at the 1% level, and values in parentheses are robust standard errors.

4.4. A Re-Examination of the Impact of Aging and Internet Usage on Farm Household Income

To further examine the moderating role of aging in Internet usage on farm household income, this section identifies rural households with a proportion of elderly people aged 60 years or older greater than or equal to 10% as the “aging group” and rural households with a proportion of elderly people aged 60 years or older less than 10% as the “non-aging group”, according to the classification criteria identified in United Nations’ The Aging of Population and Its Economic and Social Implications.

Table 7 reports the regression results of the effect of Internet usage on farm household income in different age groups. It can be seen that Internet usage has a significant positive effect on farm household income at the 1% level in both the aging and non-aging groups, which demonstrates that the Internet increases farm household income. Compared to the non-aging group, the effect of Internet usage on farm household income is smaller for the aging group, which suggests that the effect of Internet usage on farm household income

becomes smaller when considering the aging situation in rural areas. In other words, aging significantly diminishes the income-boosting effect of Internet usage, proving Hypothesis 3.

Table 7. Regression results of the impact of Internet usage on farm household income in different age groups.

Variable Name	(1) Aging Group	(2) Non-Aging Group
Internet usage	0.162 *** (0.053)	0.208 *** (0.024)
Head of household characteristic variables	Yes	Yes
Household characteristic variables	Yes	Yes
Constant	10.282 *** (0.178)	10.295 *** (0.141)
N	6085	9854
R ²	0.759	0.616
Household-fixed effect	Yes	Yes
Year-fixed effect	Yes	Yes

Note: *** indicates significance at the 1% level, and values in parentheses are robust standard errors.

4.5. The Mechanism by Which Aging Diminishes the Income-Boosting Effect of Internet Usage

According to the previous analysis, aging diminishes the impact of Internet usage on farm household income. In this section, we extend the foundation and combine theoretical analysis to examine the mechanisms of aging that diminish the income-boosting benefits of Internet usage from two perspectives: nonfarm employment and family care. As for the selection of variables, this paper draws on Li, Song [38], and Huang [39], defining any member of a farm household who works to earn wage income as non-farm employment and assigning a value of 1 and assigning 0 if no member of the household works; defining children who help the elderly with household chores or take care of food and living in the household as family care and assigning a value of 1 and assigning 0 if no children in the household assist the elderly with household chores or take care of food and living.

Table 8 reports the results of regressions testing the mechanism by which aging diminishes the income-boosting effect of Internet usage from the perspective of non-farm employment and family care. The results in columns (1) and (2) indicate that farm households engaging in non-farm employment can significantly increase household income, while aging has a significant negative impact on non-farm employment of household labor. In other words, among farm households, aging affects household income by inhibiting non-farm employment. According to the regression results in columns (3) and (4), family care significantly suppresses farm household income, while deeper aging increases the likelihood of family care, i.e., aging affects farm household income levels through increased family care. Hypothesis 4 is confirmed.

4.6. Distinguish between Different Sources of Farm Household Income

Given the current increasingly diverse income composition of rural households, this section empirically examines the heterogeneity of the effects of Internet usage and aging on different sources of farm household income. First, due to the lack of property income in the CFPS household economic questionnaire section and the fact that business income is subdivided into agricultural business income and non-farm business income, this section is limited by the data available and categorizes farm household income into four types: transfer income, non-farm business income, agricultural business income, and wage income. Second, the missing values for each type of income are filled in with the estimated values. To reduce the gap between different sources of income among farm households, the income from different sources is taken from the logarithm, as seen above. Finally, the results of the regression of different sources of farm household income are shown in Table 9, which is based on model (2).

Table 8. Regression results of the mechanism by which aging diminishes the income-boosting effect of Internet usage.

Variable Name	(1) Non-Farm Employment	(2) Farm Household Income	(3) Family Care	(4) Farm Household Income
Aging	−3.388 ** (1.448)	— —	0.569 *** (0.128)	— —
Non-farm employment	— —	0.378 *** (0.040)	— —	— —
Family care	— —	— —	— —	−0.190 *** (0.031)
Head of household characteristic variables	Yes	Yes	Yes	Yes
Household characteristic variables	Yes	Yes	Yes	Yes
Constant	−2.216 (2.683)	10.614 *** (0.153)	−11.545 *** (0.328)	10.304 *** (0.205)
N	15,939	15,939	15,939	15,939
R ²	0.709	0.661	0.613	0.654
Household-fixed effect	Yes	Yes	Yes	Yes
Year-fixed effect	Yes	Yes	Yes	Yes

Note: ** and *** indicate significance at the 5% and 1% levels, respectively, and values in parentheses are robust standard errors.

Table 9. Regression results of Internet usage and aging affecting different sources of farm household income.

Variable Name	(1) Transfer Income	(2) Non-Farm Business Income	(3) Agricultural Business Income	(4) Wage Income
Internet usage	0.146 (0.090)	0.144 (0.200)	−0.237 ** (0.114)	0.183 *** (0.052)
Aging	1.740 *** (0.107)	−1.297 *** (0.473)	−0.555 *** (0.154)	−0.719 *** (0.121)
Internet usage × Aging	1.256 ** (0.318)	−0.105 (1.238)	0.490 (0.449)	−0.627 *** (0.203)
Head of household characteristic variables	Yes	Yes	Yes	Yes
Household characteristic variables	Yes	Yes	Yes	Yes
Constant	2.374 *** (0.444)	11.556 *** (0.840)	5.230 *** (0.716)	8.997 *** (0.253)
N	11,338	15,939	15,939	15,939
R ²	0.657	0.617	0.713	0.621
Household-fixed effect	Yes	Yes	Yes	Yes
Year-fixed effect	Yes	Yes	Yes	Yes

Note: ** and *** indicate significance at the 5% and 1% levels, respectively, and values in parentheses are robust standard errors.

According to Table 9, Internet usage has inconsistent effects on farm household income. In column (1), Internet usage has no significant impact on the transfer income of farm households. According to column (4), Internet usage has a significant positive effect on the wage income of farm households at the 1% level. Under the analysis in the theoretical section, the Internet may be able to ease farm household information constraints and expand non-farm employment channels, thereby increasing household wage income. The results in columns (2) and (3) indicate that Internet usage does not have a significant effect on non-farm business income but has a negative effect on household agricultural business income, likely because Internet usage has led to a non-farm transfer of farm household labor, resulting in a decrease in agricultural income as a result of a shrinking farm labor force at a given household size.

A significant effect of aging is found on income from different sources but not in the same direction. As seen in columns (1)–(4), aging has a significant negative effect on non-farm business income, agricultural business income, and wage income of farm households but a significant positive effect on transfer income. The first three income categories are only possible with appropriate labor, and as the labor force ages, the quality and duration of labor decreases, negatively affecting the income levels of these three income categories. In recent years, however, the government has made considerable contributions to the growth of transfer income of the aging labor force through pensions, social assistance subsidies, and reimbursement of medical expenses through rural cooperative medical care.

Aging moderates the impact of Internet use on farm household income to varying extents. According to the results in column (1), aging enhances the boosting effect of Internet usage on the transfer income of farm households. There is an apparent diminishing effect of Internet usage on the wage income of farm households, as shown by the results in column (4).

5. Conclusions and Recommendations

As rural digital infrastructure construction continues to advance, the digital economy represented by the Internet has provided new momentum for rural revitalization and farmer income increases. In the background of increasingly severe aging in rural China, this paper explores the income-boosting effect of the Internet and focuses on the effects and paths of the role played by aging in Internet income-boosting. The findings are as follows. (1) The farmers' Internet usage can significantly increase their household income, but aging diminishes the income-boosting effect of Internet usage by reducing non-farm employment and increasing family care. (2) The income-boosting effects of the Internet usage are heterogeneous. The farmer' Internet usage significantly increases household wage income but reduces household farm business income. (3) Aging plays a heterogeneous moderating role in the income-boosting effects of Internet usage. Aging significantly enhances the contribution of farmers' Internet usage to household transfer income but weakens the contribution to household wage income.

According to the findings of this paper, Internet usage eases farm households' information constraints and promotes the transfer of rural labor to non-farm industries, which increases total household income through wage increases. Rural areas, however, suffer from a growing aging population and an increasing burden of family care, which hinders off-farm employment in the rural labor force and diminishes the income-boosting effects of Internet usage. Based on this, the following recommendations are made: (1) Guaranteeing farmers' accessibility to the Internet. To ensure rural households in poor areas have access to the network and can afford to use it, we must continue promoting the construction of rural digital infrastructure, conducting precise tariff reductions, discount tariffs for communication services, and other preferential initiatives. (2) Improving digital literacy and skills of farmers. We must guide enterprises and social organizations in improving farmers' digital skills, and assist farmers in obtaining timely and accurate information on work, entrepreneurship, and agricultural production through Internet usage as a "new farming tool". (3) Easing the pressure on rural families to provide for their old age. We must improve rural elderly basic service facilities, relying on local community organizations in rural areas, and utilizing the influence of external organizations to promote the availability of rural elderly services.

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