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Abstract

As entrepreneurial dynamism is widely recognized as a driver of innovation and economic growth, it is important to understand the determinants of entrepreneurship. However, there is little literature examining the role of ICT and its potential mechanisms of individual entrepreneurship in rural China. This study investigates the effect of ICT utilization on entrepreneurship and its potential mechanisms by using China Family Panel Studies (CFPS) data from 2014 to 2020. We identify Internet use via computers, Internet use via mobile devices, and Internet use by computer or mobile devices as proxy variables for ICT utilization. Our empirical results indicate that ICT utilization has a significant and positive effect on entrepreneurship in rural China. The results remain robust after a series of robustness tests. This study also finds that the effect is heterogeneous by gender, generation, educational background, and regions. Furthermore, mechanism analysis shows that the Internet can promote entrepreneurship by facilitating access to information and the formation of social capital. The above finding in rural China will have important implications for economic development and poverty reduction in other developing countries.

Keywords: information communication technology, Internet use, entrepreneurship, rural China

JEL: L26, O18, O33, R11.

1. Introduction

Entrepreneurship can promote sustainable economic growth in developing countries (Dhahri & Omri, 2018). Factors influencing entrepreneurship are also of great academic interest because entrepreneurship can solve employment problems in developing countries (Mel & Woodruff, 2007; Faggio & Silva, 2014). Particularly, in rural areas where economic backwardness and seasonal unemployment are common, the role of entrepreneurship influenced by information and communication technologies (ICTs) is essential (Wang et al., 2024). By becoming entrepreneurs, rural residents can increase their wealth and contribute to economic development in rural areas (Nie et al., 2024). In recent years, China has been encouraging the establishment of new firms based on entrepreneurship under the slogan “Widespread Entrepreneurship and Innovation,” and there are high hopes for the spread of self-employment in rural areas (Murakami, 2019). In addition,

the report of the 19th National Congress of the Communist Party of China stated the need to "promote the integrated development of the primary, secondary, and tertiary industries, support and encourage employment and business startups in rural areas and open up more channels to increase rural incomes". Furthermore, under the guidance of the "Internet+" strategy, entrepreneurship in rural areas has become an important driving force for rural revitalization (Peng & Zeng, 2020). However, the level of entrepreneurship in rural areas remains significantly lower than in urban areas (Zhou et al., 2023).

China's Internet era began in 1994, and the Internet infrastructure was rapidly developed and has since been widely used in various industries and fields (Tan & Li, 2022). Since the 1990s, the Internet has developed rapidly in China. According to the China Internet Network Information Center (CNNIC), the number of Internet users in China reached 1.092 billion by the end of 2023, with an Internet penetration rate of 77.5%. In addition, by the end of 2023, the number of Internet users in rural areas reached 326 million, and the Internet penetration rate reached 66.5%, showing that the Internet environment has greatly improved in rural areas. With the popularization of the Internet, the entrepreneurial environment has undergone drastic changes. In the current economic and social climate, there is real significance in conducting detailed research regarding the impact of the Internet on entrepreneurial decision-making and entrepreneurial income, and the mechanisms involved (Liu et al., 2021).

Previous studies have investigated the factors that determine entrepreneurship from various perspectives, including institutions, financial constraints, social resources, and individual characteristics (Blanchflower & Oswald, 1998; Gedajlovic et al., 2013). However, the impact of ICT use on entrepreneurship has not received much attention (Barnett et al., 2019). ICT is an umbrella term for information technology (IT), which covers a wide range of technological fields, including computer and network technology, communication satellites, broadcast media, mobile phones and wireless networks (Dong et al., 2024). The Internet is an important component of ICT (Nie et al., 2024). The Internet can affect entrepreneurship by providing information and knowledge about entrepreneurship and expanding social networks.

Developing countries generally face the problem of developing rural entrepreneurship and revitalizing rural areas (Bigman, 2002), and China's experience is valuable for many developing countries (Gu, 2024). In addition, there are still few previous studies on the impact of the Internet on entrepreneurship in developing countries. Empirical research on China has important implications for other developing countries (Tan & Li, 2022). Therefore, this study uses large-scale microdata representative of China to quantitatively clarify the effects of ICT use on entrepreneurship in rural China, the heterogeneity of these effects, and the potential mechanisms.

This paper contributes to the existing literature in the following four ways. First, it focuses on rural China and individuals and analyzes ICT use by dividing it into three usage patterns: Internet use on computers, Internet use on mobile devices, and Internet use on computers or mobile devices.

Most of the previous studies have focused on urban areas and have measured entrepreneurship at the household level. Therefore, this study can fill the gap in previous research.

Second, this study analyzes the relationship between Internet use and entrepreneurship, including potential mechanisms. Previous research on the impact of Internet use on entrepreneurship in rural China and its mechanisms is lacking, and there is room for improvement. This study examines the potential mechanisms of information gathering, social capital, and attitudes towards Internet use.

Third, this study examines the heterogeneity of the effects of Internet use on entrepreneurship. In addition to different internet usage patterns, this study examines the heterogeneity of effects by analyzing by gender, generation, educational background, and region.

Fourth, from the perspective of methodology, we conduct panel data analysis using the four waves of CFPS data. Previous studies have mainly adopted cross-sectional data research, and there is little empirical evidence using panel data.

The structure of this paper is as follows. Section 2 reviews previous studies and develops hypotheses. Section 3 explains data and methodology. Section 4 presents the empirical results. Finally, Section 5 presents the conclusions and policy implications.

2. Literature review

2.1. Entrepreneurship in rural China

Previous research on entrepreneurship in rural areas of emerging and developing countries, including China, has examined a number of factors that influence entrepreneurship. In terms of individual characteristics, there is a significant and positive relationship between religious beliefs and farmer entrepreneurship in rural China (Miao et al., 2021). Furthermore, gender (Rijkers & Costa, 2012), social capital (Poon et al., 2012), and childhood adversity (Cheng et al., 2021) also affect entrepreneurship. Household resources also affect entrepreneurship. For example, family financial constraints limit entrepreneurial activities (Paulson & Townsend, 2004). Similarly, household credit constraints have a negative impact on entrepreneurship (Cai et al., 2018). Furthermore, many factors related to the environment may affect entrepreneurship (Nie et al., 2024).

Rural entrepreneurship faces many challenges, such as poor socioeconomic environments, aging populations, and a lack of resources such as social networks and financial support (Liu et al., 2022). To promote entrepreneurship, the Chinese government has implemented a series of policies. In 2015, the government launched the “mass entrepreneurship and innovation” campaign, creating a favorable environment for entrepreneurship and encouraging people to actively engage in entrepreneurship. There are also many support policies in place, including tax incentives and subsidies.

2.2. Internet Use in Rural China

The development of ICT has led to the rapid spread of the Internet in rural areas. In China, broadband access has been made available in all rural areas by the end of November 2021. According to the CNNIC, at the end of 2013, the number of rural internet users was 177 million, and the internet penetration rate in rural areas was 28.1%. However, at the end of 2023, the number of rural internet users was 326 million, and the internet penetration rate was 66.5%, showing that the internet has rapidly spread in rural areas over the past 10 years. The background to this is that in August 2013, the State Council released the implementation plan of the "Broadband China" strategy, and China's internet penetration rate has risen to a national strategy. Many existing studies have found that farmers have benefited greatly from the Internet (Vatsa et al., 2022). The Internet has played a positive role in lifting rural residents out of poverty and increasing income and consumption (Gao et al., 2018; Ma et al., 2020). The Internet also has a positive impact on household savings (Zeng et al., 2023). Furthermore, it was shown that Internet use has a positive and statistically significant impact on the number of sustainable agricultural practices adopted (Ma & Wang, 2020).

2.3. Internet Use and Entrepreneurship

Against the backdrop of the rapid development of ICT centered on the Internet, empirical studies on the impact of Internet use on entrepreneurship have been increasing in recent years (Liu et al., 2021; Zhou & Gang, 2018). There are also several empirical studies on the impact of Internet use on entrepreneurship in rural China. For example, Tan and Li (2022) found that the Internet has a positive impact on family entrepreneurship, and the mechanism is that it makes it easier for entrepreneurs to obtain information and secure informal financing. In addition, Song and He (2021) found that the Internet has a positive impact on family entrepreneurship, and that the mechanisms include information acquisition, social capital, and financing. Zhou et al (2023) examined four aspects of Internet use: online information gathering, online learning, online social participation, and online business, and found that all had a positive impact on family entrepreneurship. Liu et al. (2021) found that Internet use has a significant positive impact on family entrepreneurial intentions and entrepreneurial income, and that the mechanism is to enrich the family social network. Zhao (2020) found that Internet use increases the probability of self-employment in rural areas, and that the effect varies by gender, generation, and education. However, there is still a lack of panel data analysis on the impact of Internet use on individual-level entrepreneurship. As one of the few exceptions, Barnett et al. (2019) found that mobile phone and Internet use have a positive impact on entrepreneurship and that the impact of ICT use on entrepreneurship is mediated by social networks and online information acquisition.

Internet use in rural China removes barriers to information and helps rural people access new information and advanced knowledge. People in rural China access Internet resources to obtain

information related to production and management. This not only reduces the cost of information retrieval, but also helps entrepreneurs improve speed, efficiency, and accuracy, and seize business opportunities (Wang et al., 2024). Therefore, we develop Hypothesis 1 as follows.

Hypothesis 1: *Internet use promotes the entrepreneurship of rural residents.*

We examine the mechanisms by which the use of ICTs affects entrepreneurship. The mechanisms identified by several previous studies can be classified into two categories: mechanisms for acquiring information and knowledge and mechanisms for social networks (Barnett et al., 2019).

The first is the effect of Internet use to acquire information and knowledge. The ability to discover entrepreneurial opportunities, that is, situations in which the revenue exceeds the investment cost in the product market or factor market, is the first step towards entrepreneurship (Barnett et al., 2019). Shane and Venkataraman (2000) found that two factors are necessary for identifying entrepreneurial opportunities: the possession of the prior information necessary to identify an opportunity and the cognitive properties necessary to value it. In the process of discovering entrepreneurial opportunities, it is necessary to obtain sufficient information to trigger entrepreneurial speculation. Therefore, those who have more information are more likely to become entrepreneurs than those who have less information. As an important element of Internet applications, search engines help potential entrepreneurs obtain a wealth of information online and promote the ticketing of entrepreneurial opportunities (Zhou et al., 2023). In addition, the Internet provides a source of knowledge necessary for entrepreneurship, enhances the ability of entrepreneurs to carry out their business, and increases the probability of entrepreneurial success (Conley & Udry, 2010). The use of the Internet can facilitate the exchange of information and mitigate information asymmetry when people make entrepreneurial decisions (Tan & Li, 2022). Therefore, online information acquisition may facilitate entrepreneurship by making it easier for individuals to identify entrepreneurial opportunities. We develop Hypothesis 2 as follows.

Hypothesis 2: *Internet use promotes online information acquisition.*

The second is the effect of Internet use in expanding social networks and social capital. From a conceptual perspective, Internet use can have both negative and positive effects on social capital (Bauemschuster et al., 2014). On the one hand, if the Internet is mainly used for passive entertainment, it can have a negative effect on social capital, in the same way as television. Shopping and banking transactions through the Internet can deprive people of face-to-face interaction (Franzen, 2003).

On the other hand, there are also positive effects of the Internet on social capital. The information function of the Internet makes it easier to obtain information about the location and date of social events, reduces the transaction costs of booking places and purchasing tickets for specific events, and provides information about politics and civic activities. Furthermore, the communication function of the Internet can make social interaction more convenient and efficient

(Pénard & Poussing, 2010), and it may also promote interpersonal interaction by synchronizing communication in time and space (Bauemschuster et al., 2014). Therefore, Internet use reduces the temporal and spatial distance between people, greatly reduces the cost of information exchange, and thereby expands people's social networks (Liu et al., 2021). Internet use helps entrepreneurs expand their social relationships from family relationships to market networks (Fan, 2002). In China, communication tools created by the development of the Internet, such as WeChat and Weibo, have greatly enriched people's social lives and strengthened the social networks of entrepreneurs. In rural China, a transformation from tradition to modernity has occurred since the 1980s. The digital economy, symbolized by the Internet and new media, has reduced the distance between rural China and the world, and eliminated the isolation of traditional villages (Wang et al., 2024).

There is also evidence that Internet use in rural China has alleviated the constraints on social capital (Zhao, 2020). Empirical studies have revealed the positive impact of social networks on entrepreneurship (Gedajlovic et al., 2013; Khoshmaram et al., 2020). The main reason is that social networks help potential entrepreneurs to raise funds. People in rural areas have difficulty raising sufficient start-up capital from formal financial institutions due to discrimination and collateral restrictions (Bai et al., 2006). Therefore, informal financing through social networks is the main form of financing in rural areas (Barnett et al., 2019). Based on the above, we develop Hypothesis 3 as follows.

Hypothesis 3: *Internet use promotes social networks and social capital.*

Finally, Internet use for various information searches, live influencer marketing, and watching popular short videos are likely to have a positive impact on the importance and awareness of using the Internet for work and business (commercial activities). China has experienced a period of rapid Internet penetration among its residents, which has had a significant impact on entrepreneurial activity in the country (Barnett et al., 2019; Tan & Li, 2022; Wang et al., 2024). According to AliResearch, by 2021, more than one million farmers were engaged in online entrepreneurship on the Taobao platform. In recent years, live streaming has become a new business model on digital platforms such as Taobao, Douyin, and Kuaishou, and live streamers are often considered to be a new type of entrepreneur (Sun et al., 2024). Therefore, if the recent development of e-commerce in rural areas improves attitudes toward using the Internet for business purposes, it will increase entrepreneurial motivation and have a positive impact on entrepreneurship. Based on the above, we propose Hypothesis 4 as follows.

Hypothesis 4*: Internet use improves attitudes towards using the Internet for business.*

3. Data & Methodology

3.1. Data

We use panel data constructed from the China Family Panel Studies (CFPS) data. The CFPS is a nationally representative, biannual longitudinal survey project that began in 2010 by the Institute

of Social Science Survey of Peking University. CFPS data collects data at the individual, family, and community levels. The most recent data available is from 2020. We use four-period panel data constructed from CFPS data from 2014, 2016, 2018, and 2020. The reason for using CFPS data from 2014 onwards is that the CFPS began incorporating a mobile phone and internet module from 2014 onwards. Two screenings are applied to the sample. First, as the analysis in this paper focuses on individual labor choices, the sample is limited to individuals aged 18 to 60. Second, because we focus on rural areas, the sample is limited to individuals living in rural areas.

In addition to the CFPS, we obtained provincial-level socioeconomic variables from the China Statistical Yearbook.

3.2. Variables

3.2.1 Dependent variables

The dependent variable is individual entrepreneurship. To define individual entrepreneurship, we relied on two questions in the CFPS questionnaire: “Do you work for yourself/family or are you employed by others/organizations/units/companies?” and “Is your job an agricultural job or a non-agricultural job?” Referring to Barnett et al. (2019), Zhao (2020), and Lyu (2023), we defined entrepreneurship as individual who works for himself/family and whose work is non-agricultural.

3.2.2. Independent variables

The independent variables are several indicators of ICT use in the CFPS. The use of Internet technology is investigated from three perspectives. The first is whether the individual uses the Internet on computers (1 if yes, 0 if no), the second is whether the individual uses the internet on mobile devices (1 if yes, 0 if no), and the third is whether the individual uses the Internet on either computers or mobile devices (1 if yes, 0 if no).

3.2.3. Control variables

Referring to previous studies (Cai et al., 2018; Barnett et al., 2019, Miao et al., 2021), we include individual, family, and regional-level control variables that may affect the likelihood of entrepreneurship. We include control variables related to individual demographic characteristics (age, gender, marital status, education, health status, and hukou), family characteristics (number of family members), and regional characteristics in the province where the person lives (GDP per capita, unemployment rate, ratio of government expenditure to GDP, number of private firms, average wage of employed persons in urban units, per capita disposable income of rural residents, and population density).

3.3. Methodology

To examine the impact of Internet use on entrepreneurship, we use a fixed effect (FE) model. The main advantage of this model specification is that it allows for the inclusion of individual fixed effects, which allows us to identify the effects of unobserved time-invariant heterogeneity between individuals. Although logit models are sometimes used for binary dependent variables, FE logit is not suitable for our case because it excludes all respondents whose dependent variable values do not change across panels, resulting in significant data loss (Sun et al., 2024). Therefore, we report the results based on the FE model. The equation is specified as follows:

$$Entrepreneurship_{it} = \beta_0 + \beta_1 Internet_{it} + \beta_2 \boldsymbol{X}_{it} + \mu_i + \lambda_t + \varepsilon_{it}, \quad (1)$$

where the dependent variables $Entrepreneurship_{it}$ is a dummy variable indicating whether individual i chooses entrepreneurship in time t. The core independent variable $Internet_{it}$ is the dummy variable indicating Internet use. The coefficient β_1 reflects the impact of Internet use on entrepreneurship. $\boldsymbol{X}_{it}$ denotes a set of observable control variables including age, gender, marital status, years of education, health status, hukou, and family size. μ_i denotes individual fixed effects, λ_t denotes year fixed effects, and ε_{it} denotes the error term.

Eq. (1) is estimated using two-way fixed effects (TWFE), controlling for both individual fixed effects μ_i to mitigate the impacts of time-invariant individual characteristics and unobservables, such as family backgrounds and initial capital, which may influence entrepreneurial decisions, as well as year (wave) fixed effects λ_t to address the unobserved influence of secular changes and common shocks over time. In addition, we control for province fixed effects to address the impact of unobservables, such as culture and institutions that are common within a province.

Table 1 provides a detailed description, and descriptive statistics of the variables used in our analyses. Table 1 shows that entrepreneurs accounts for 10.9% in rural China. The primary independent variable is Internet use. Of our sample, 24.5% use the Internet on computers, 51.9% use the Internet on mobile devices, and 57.6% use the Internet on either computers or mobile devices.

Table 1 Descriptive statistics

Variable	Variable definitions	Obs	Mean	Std. dev.	Min	Max
Entrepreneurship	An indicator variable of individual who works for himself/family and whose work is a non-agricultural	101,300	0.109	0.311	0	1
PC internet	An indicator variable of using the Internet on computer	122,576	0.245	0.430	0	1
Mobile internet	An indicator variable of using the Internet on mobile devices	90,981	0.519	0.500	0	1
Internet use on PC or mobile devices	An indicator variable of using the Internet either on computer or mobile devices	100,423	0.576	0.494	0	1
Age	The age	139,891	45.131	18.453	9	104
Male	Male =1, otherwise =0	139,908	0.499	0.500	0	1
Married	Married =1, otherwise =0	127,643	0.767	0.423	0	1
Education	Years of education	135,555	7.310	4.982	0	21
Health	Self-rated health status	139,100	2.964	1.247	1	5
Information	The Internet as an important source of access to information =1, otherwise =0	122,406	0.369	0.482	0	1
Social capital	The total expenditure spent on gifts for social relations (RMB)	129,603	4249.320	6774.994	0	350000
Importance of the Internet for work	The importance of the Internet for work (1–5 scale: 1 is very unimportant and 5 is very important)	32,840	3.789	1.294	1	5
Importance of the Internet for commercial activities	The importance of the Internet for commercial activities (1–5 scale: 1 is very unimportant and 6 is very important)	40,716	3	1.341	1	5
Family size	The number of family members	137,459	4.354	2.045	1	21
Ln(GDP per capita)	Natural logarithm of GDP per capita	139,483	10.853	0.413	10.182	12.013
Unemployment rate	Unemployment rate	139,483	0.032	0.006	0.013	0.046

Fiscal expenditure/GDP	Ratio of government expenditure to GDP	139,483	0.240	0.094	0.119	1.379
Ln(number of private firms)	Natural logarithm of number of private firms	139,483	12.707	0.973	8.599	14.819
Ln(average wage)	Natural logarithm of average wage of employed persons in urban units	139,483	11.110	0.284	10.650	12.091
Ln(income of rural residents)	Natural logarithm of per capita disposable income of rural residents	139,483	9.458	0.352	8.745	10.461
Ln(population density)	Natural logarithm of population density	139,483	5.738	1.022	1.012	8.281

4. Results

4.1. Main results

Table 2 presents the results of two-way fixed effects (TWFE) estimation[1]. The main findings are as follows. First, in column 1, the coefficient of Internet use on computer is significantly positive at the 10% significance level. Thus, the result shows that Internet use on computers can increase the probability of entrepreneurship. Second, in column 2, the coefficient of Internet use on mobile devices is significantly positive at the 5% significance level. The result indicates that Internet use on mobile devices can significantly increase entrepreneurship. Third, in column 3, the coefficient of Internet use on either computer or mobile devices is significantly positive at the 5% significance level. The result indicates that Internet use, whether on computers or mobile devices, can significantly increase entrepreneurship. Therefore, Hypothesis 1 is supported. Possible reasons for this are as follows. Using the Internet can lead to the acquisition of timely information and knowledge related to starting a business, and it can increase motivation to start a business. This can have a positive impact on entrepreneurship. Moreover, new forms of entrepreneurship, such as selling products via live streaming, are widely accepted (Nie et al., 2024).

Table 2 The impact of ICT on entrepreneurship.

	(1)	(2)	(3)
VARIABLES	Entrepreneurship		
PC Internet	0.014*		
	(0.007)		
Mobile Internet		0.011**	
		(0.005)	
Internet use on PC or mobile devices			0.012**
			(0.005)
Individual-level control variables	Yes	Yes	Yes
Household-level control variables	Yes	Yes	Yes
Province-level control variables	Yes	Yes	Yes
Region fixed effects	Yes	Yes	Yes

[1] As Sun et al. (2024) argue, the estimates for the main effect of Internet-use, many of the control variables, and R-squared levels of models are small in size due to the inclusion of year fixed effects as well as individual fixed effects. In particular, when individual fixed effects are in the models, inference is based on within-person variations, which tend to be small for our window of observation for each individual. The estimated effects for Internet-use in the random-effects (RE) models without individual fixed effects are much larger.

Year fixed effects	Yes	Yes	Yes
Constant	-0.310	-0.334	-0.737
	(1.045)	(1.782)	(1.706)
Observations	36,036	25,936	28,404
Number of pid	16,007	13,998	14,581
Within R-squared	0.005	0.007	0.006

Note: Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1 Control variables include age, age squared, gender, marital status, years of education, health status, hukou, family size, GDP per capita, unemployment rate, ratio of fiscal expenditure to GDP, number of private firms, average wage of employed persons in urban units, per capita income of rural residents, and population density.

4.2. Omitted variable bias

Despite including a comprehensive range of control variables, the possibility of omitted variable bias remains a valid concern. For instance, the relationship between ICT and entrepreneurship may be affected by unobserved factors such as regional policy differences, access to financial resources, or informal networks may significantly influence both ICT adoption and entrepreneurial success. To ensure the reliability of our findings, we conduct a robustness analysis to evaluate the potential bias arising from unobservable factors. This analysis employs the partial identification method introduced by Oster (2019), which has been intensively used in existing literature to address concerns of omitted variable bias (González, 2020; Kaila & Tarp, 2019; Nguyen-Phung & Le, 2024). This study assesses the magnitude of selection bias on unobservable variables in relation to observable variables to account for the effect of ICT on entrepreneurship. The bias-adjusted coefficient derived by Oster (2019) is computed in the following manner:

$$\beta^* = \tilde{\beta} - \delta\left[\dot{\beta} - \tilde{\beta}\right]\frac{R_{max}-\tilde{R}}{\tilde{R}-\dot{R}} \qquad (2)$$

The coefficient and R^2 value obtained from a regression analysis with ICT as the only independent variable are denoted as $\dot{\beta}$ and $\dot{R}$. On the other hand, the coefficients and R^2 values from a regression analysis with ICT as well as the observed controls are denoted as $\tilde{\beta}$ and $\tilde{R}$. δ refers to the relative significance of observable variables compared to unobservable variables in causing bias, whereas R_{max} represents the R^2 derived from a hypothetical regression model that incorporates both observable and unobservable variables. In order to address the uncertainty surrounding the unknown values of δ and R_{max}, Oster (2019) suggests employing a bounding approach. This approach entails estimating the effect of ICT on entrepreneurship outcome within a range of values, denoted as $\tilde{\beta}$ to β^*. This estimation is made under the assumption that $\delta = 1$ and with the constraint that $R_{max} \in [\tilde{R}, 1]$. According to Oster (2019), the recommendation for R_{max} relies on published empirical work derived from randomized control studies in reputable economics journals between 2008 and 2013. The proposed approach suggests that $R_{max} =$

$min\{1.3\tilde{R}, 1\}$. We adhere to this approach to calculate the maximum value of R^2 and its corresponding bounds. The robustness results can be established if the identified set $[\tilde{\beta}, \beta^*]$ does not include zero. We also adopt the approach Oster (2019) proposed to compute the parameter δ. In this context, a value of $\delta > 1$ would suggest that the observable variables are more significant than the unobservable variables in elucidating the outcome variables, thereby confirming the presence of robust findings.

The results of the Oster's (2019) analysis are shown in Table 3. We first present the estimation of δ and assess its potential value exceeding 1. Furthermore, we report the bounds of the coefficient. The first bound $\tilde{\beta}$ is derived from the linear estimation, including control variables used in all estimations. The computation of the second bound β^* is performed by utilizing Equation (2) and employing the rule of thumb suggest by Oster (2019), which involves setting $R_{max} = min\{1.3\tilde{R}, 1\}$. The obtained findings offer a degree of assurance in the robustness of our main findings to the exclusion of certain variables, as indicated when $\delta > 1$. This suggests that the unobservable variables would need to exert a more substantial influence on entrepreneurship than the observable variables to impact our findings significantly. Moreover, the estimated bounds derived from our analysis effectively dismiss the possibility of a null effect when the estimated bound excludes zero.

Table 3. Oster's (2019) test of omitted variable bias.

Variables	Proportionality	Identified set		
	$\delta_{(R_{max}=min\{1.3\tilde{R},1\})}$	$\delta > 1$	$[\tilde{\beta}, \beta^*_{(R_{max}=min\{1.3\tilde{R},1\},\delta=1)}]$	Excludes 0?
PC Internet	12.169	Yes	[0.014, 0.015]	Yes
Mobile Internet	8.505	Yes	[0.011, 0.006]	Yes
Internet use on PC or mobile devices	30.734	Yes	[0.012, 0.010]	Yes
Controls	Yes			

4.3. Heterogenous effects

As the impact of ICT on entrepreneurship can be heterogeneous among groups, this part examines the heterogeneity of the impact of Internet use on entrepreneurship in rural areas from four perspectives, gender, generation, education level, and regions. The two-way fixed effects (TWFE) estimation results are shown in Table 4. Panel A presents the results of sub-samples: female and

male. As columns (1)-(3) show, the coefficient of Internet use for female is insignificantly positive. On the contrary, as columns (5) and (6) show, the coefficient of Internet use on mobile devices and that of Internet use on either computer or mobile devices is significantly positive, respectively. The results indicate that Internet use whether on computer or mobile devices can significantly increase entrepreneurship for male. One possible reason for this is that in rural areas, the role of females is mainly to take care of the family. They may use the Internet more for childcare, online shopping, and housework. On the contrary, males may spend more time for obtaining market information, business opportunities, and online contents on successful experiences of many other entrepreneurs.

Panel B presents the results of sub-samples: younger generation and older generation. As column (1) shows, the coefficient of Internet use on computer for younger generation is significantly positive. On the contrary, as columns (5) and (6) show, the coefficient of Internet use on mobile devices and that of Internet use on either computer or mobile devices is significantly positive, respectively. The results indicate that while Internet use on computer can significantly increase entrepreneurship for younger generation, Internet use whether on computer or mobile devices can significantly increase entrepreneurship for older generation. One possible reason for this is that, unlike the younger generation, the older generation find it difficult to fully master how to use computers, so it is difficult to link computers to entrepreneurship.

Panel C presents the results of sub-samples: high-level education (years of education is over 15) and middle and low-level education (years of education is less than 15). As column (3) shows, the coefficient of Internet use on either computers or mobile devices for those with high-level education is significantly negative. On the contrary, as columns (4) - (6) show, the coefficient of Internet use is significantly positive, respectively. The results indicate that while Internet use can significantly decrease entrepreneurship for those with high-level education, Internet use can significantly increase entrepreneurship for those with low-level education. One possible reason for this is that rural residents with a college degree or higher often use the Internet to find low-risk, stable employment opportunities, such as white-collar work in urban areas that make use of their expertise, rather than starting their own business. On the contrary, low-educated rural residents often have to choose between becoming rural migrant workers or becoming entrepreneurs, and if there is even a small chance of success, they may choose to become entrepreneurs. In general, rural residents with high educational standards have a high level of skill in obtaining information via the Internet and use the Internet more frequently, thus the scope of their use of the Internet is wider and they have more options other than being entrepreneurs.

Panel D presents the results of sub-samples: the East, Central, and West regions. On the one hand, as columns (1) - (3) and (7) – (10) show, the coefficient of Internet use is insignificantly positive. On the other hand, as columns (4) - (6) show, the coefficient of Internet use is significantly positive. The results indicate that while Internet use may not increase entrepreneurship in either East China or West China, Internet use can significantly increase entrepreneurship in Central China. One possible reason for this is that there are more opportunities for entrepreneur because rural e-commerce has been growing at the fastest rate in Central China.

Table 4 Heterogeneous impact of ICT among different groups

Panel A	Female			Male		
	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	Entrepreneurship			Entrepreneurship		
PC Internet	0.010			0.015		
	(0.010)			(0.010)		
Mobile Internet		0.007			0.016*	
		(0.006)			(0.008)	
Internet use on PC or mobile devices			0.007			0.018**
			(0.006)			(0.008)
Individual-level control variables	Yes	Yes	Yes	Yes	Yes	Yes
Household-level control variables	Yes	Yes	Yes	Yes	Yes	Yes
Province-level control variables	Yes	Yes	Yes	Yes	Yes	Yes
Region fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Constant	-0.412	-0.215	-2.076	-0.512	-0.723	0.282
	(1.412)	(2.255)	(2.348)	(1.531)	(2.723)	(2.425)
Observations	17,294	12,548	13,574	18,742	13,388	14,830
Number of pid	7,656	6,704	6,981	8,368	7,311	7,617
Within R-squared	0.007	0.017	0.011	0.009	0.012	0.012

Panel B	Younger (18-34)			Older (35-60)		
	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	Entrepreneurship			Entrepreneurship		
PC Internet	0.021**			0.011		
	(0.010)			(0.011)		
Mobile Internet		0.007			0.014**	
		(0.014)			(0.006)	
Internet use on PC or mobile devices			0.005			0.012**
			(0.014)			(0.006)
Individual-level control variables	Yes	Yes	Yes	Yes	Yes	Yes
Household-level control variables	Yes	Yes	Yes	Yes	Yes	Yes
Province-level control variables	Yes	Yes	Yes	Yes	Yes	Yes
Region fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Constant	0.538	-4.224	1.410	0.056	1.260	-1.621
	(2.879)	(4.903)	(3.386)	(1.093)	(1.878)	(1.881)
Observations	10,921	7,900	9,740	25,115	18,036	18,664
Number of pid	6,198	5,140	5,754	10,695	9,395	9,497
Within R-squared	0.012	0.017	0.012	0.005	0.009	0.009

Panel C	High-level education			Middle and low-level education		
	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	Entrepreneurship			Entrepreneurship		
PC Internet	-0.019			0.018**		
	(0.017)			(0.008)		
Mobile Internet		-0.033			0.013**	
		(0.028)			(0.005)	
Internet use on PC or mobile devices			-0.061**			0.015***
			(0.028)			(0.005)
Individual-level control variables	Yes	Yes	Yes	Yes	Yes	Yes
Household-level control variables	Yes	Yes	Yes	Yes	Yes	Yes
Province-level control variables	Yes	Yes	Yes	Yes	Yes	Yes
Region fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Constant	4.149	-10.584*	-0.814	-0.281	0.350	-0.575
	(6.475)	(5.566)	(6.383)	(1.066)	(1.881)	(1.809)
Observations	3,227	2,231	2,572	33,888	24,187	26,327
Number of pid	2,389	1,649	1,787	14,832	12,935	13,420
Within R-squared	0.063	0.072	0.074	0.004	0.006	0.005

Panel D	East			Central			West		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
VARIABLES	Entrepreneurship			Entrepreneurship			Entrepreneurship		
PC Internet	0.010			0.024*			0.005		
	(0.012)			(0.013)			(0.012)		
Mobile Internet		0.003			0.022*			0.008	
		(0.010)			(0.012)			(0.007)	
Internet use on PC or mobile devices			0.008			0.024**			0.006
			(0.010)			(0.011)			(0.007)
Individual-level control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Household-level control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Province-level control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Region fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	-2.326	-4.702	-8.096**	-0.895	10.325*	2.020	-4.612	-5.612	2.098
	(3.419)	(4.306)	(3.856)	(2.568)	(5.684)	(4.329)	(6.252)	(13.990)	(11.909)
Observations	12,407	8,658	9,681	9,832	6,945	7,699	13,797	10,333	11,024
Number of pid	5,547	4,710	4,969	4,384	3,762	3,964	6,210	5,620	5,763
Within R-squared	0.010	0.012	0.016	0.005	0.009	0.008	0.008	0.010	0.011

Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

4.4. Potential pathways

Table 2 shows that ICT use has a positive impact on entrepreneurship. This study considers three potential pathways, namely information channel, social capital, and attitude towards using ICT to explore how Internet use affects entrepreneurship. The two-way fixed effects (TWFE) estimation results are shown in Table 5.

First, we investigate the impact of Internet use on information channel. In general, people can use the Internet to obtain information resources conveniently and efficiently. Therefore, the Internet has a strong information effect, especially for entrepreneurs (Tan & Li, 2022). The information channel is measured by asking whether the Internet is an important source of information. As columns (1) - (3) show, the coefficient of Internet use is significantly positive at the 1% significant level. The result indicates that the Internet use facilitates entrepreneurs to obtain information. Therefore, Hypothesis 2 is supported.

Second, we investigate the impact of Internet use on social capital. Online messaging services like WeChat have the potential to supplement interpersonal communication and strengthen people's social networking. Traditionally, small business owners in rural areas have relied heavily on social capital and social networking to facilitate the smooth operation of their businesses. Internet use provides an efficient way to maintain existing social connections and create new ones. In China, social capital involving kinship networks is one of the most important elements of Chinese culture throughout people's lives (Wang & Rowley, 2017). The "cash in gifts" at certain ceremonial occasions, such as weddings is one of the prominent ways to maintain existing social connections in China (Hsu, 2005). Referring to Zhao (2020) and Zhou et al. (2023), social capital channel is measured by the total expenditure spent on gifts for social relations. As columns (4) - (6) show, the coefficient of Internet use is significantly positive at the 1% significant level. The result indicates that the Internet use facilitates entrepreneurs to maintain existing social connections and create new ones. This can encourage entrepreneurship by lessening social capital restrictions. Therefore, Hypothesis 3 is supported.

Third, we investigate the impact of Internet use on the attitudes toward Internet use for work and commercial activities. By using the Internet, people will come to understand the various useful functions and positive roles of the Internet, and they may come to think that it is important to use the Internet for work and commercial activities. The attitudes toward Internet use are measured by asking whether the Internet is important in terms of work and whether the Internet is important in terms of commercial related activities. As columns (7) and (10) shows, the coefficient of Internet use on computers is significantly positive at the 10% significant level. The result indicates that the Internet use on computer facilitates entrepreneurs to have positive attitudes toward the Internet for work and commercial related activities. Therefore, Hypothesis 4 is partly supported.

Table 5 Potential mechanisms

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
VARIABLES	information channel			social capital channel			importance for work			importance for commercial activities		
PC Internet	0.093***			0.121***			0.107*			0.088*		
	(0.011)			(0.041)			(0.063)			(0.049)		
Mobile Internet		0.209***			0.179***			0.319			0.124	
		(0.011)			(0.046)			(0.217)			(0.184)	
Internet use on PC or mobile devices			0.220***			0.188***						
			(0.010)			(0.044)						
Individual-level control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Household-level control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Province-level control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Region fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	4.009**	0.061	-0.170	-13.005	5.786	-5.117	-42.563**	-45.051	-42.503**	1.989	25.096	1.314
	(1.906)	(3.598)	(2.821)	(8.779)	(17.556)	(12.646)	(17.697)	(28.822)	(17.698)	(16.929)	(21.411)	(16.964)
Observations	40,734	29,316	32,415	38,627	29,024	31,733	9,457	8,335	9,457	12,337	11,085	12,337
R-squared	0.132	0.131	0.127	0.019	0.021	0.021	0.052	0.049	0.050	0.266	0.269	0.265
Number of pid	17,840	15,570	16,278	17,375	15,510	16,123	7,109	6,633	7,109	8,310	7,905	8,310

Note: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

5. Conclusions

We use the micro data from the China Family Panel Survey (CFPS) from 2014 to 2020 to empirically examine the impact of Internet use on entrepreneurship and its heterogeneity, and its potential mechanisms. Using two-way fixed effects (TWFE) models, we find that individual Internet use have positive impacts on entrepreneurship. These results remain robust after a series of robustness checks. Moreover, we find that heterogeneous effects of Internet use on entrepreneurship exist in gender, generation, educational background, and regions. Specifically, positive impact of Internet use on entrepreneurship is statistically significant for male, middle and low-level education, and Central China. We also investigated various potential mechanisms through which Internet use may affect entrepreneurship. These mechanisms include information channel, social capital channel, and the attitudes toward Internet use for work and commercial activities. Our findings are in line with previous studies which find that ICT utilization such as cell phone ownership and Internet use has a positive impact on entrepreneurship in China (Barnett et al., 2019; Tan & Li, 2022; Nie et al., 2024).

Our findings provides beneficial policy implications. Policy makers can further invest in ICT infrastructure to accelerate the spread of the Internet in rural areas, thereby providing a better environment for fostering the entrepreneurship in rural areas. More training programs can also be set up to help rural residents use the Internet and other ICT and support them in starting up their own businesses. Considering the heterogeneity effect of Internet use, the ICT training program will be more effective for male, middle and low-level education. The positive impact of the Internet use on the entrepreneurship of rural residents should be a focus of attention in rural development.

There are two main limitations for this paper. First, this study does not measure the actual information acquisition situation but rather asks respondents for their opinions on how important they think the Internet is for acquiring information. Second, this study only examines the impact of ICT use on the probability of transitioning to entrepreneurship. Further research is needed to examine how ICT use affects the entrepreneurial performances such as profitability and survival rate of entrepreneurship.

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Appendix

As entrepreneurship is a binary variable in this study and some researchers use the Probit models (Tan & Li, 2022; Wang et al., 2024), we use Random effects (RE) Probit model for robustness checks. Table A1 presents the result. As columns (1) – (3) show, the coefficient of Internet use is significantly positive at the 1% significance level. The result indicates that Internet use can significantly increase entrepreneurship. Therefore, the baseline results are robust.

Table A1 Random effects (RE) Probit estimate

	(1)	(2)	(3)
VARIABLES	Entrepreneurship		
PC internet	0.321***		
	(0.053)		
Mobile internet		0.452***	
		(0.061)	
Internet use on PC or mobile devices			0.485***
			(0.059)
Individual-level control variables	Yes	Yes	Yes
Household-level control variables	Yes	Yes	Yes
Province-level control variables	Yes	Yes	Yes
Region fixed effects	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes

Constant	-9.922	-21.807	-9.854
	(14.763)	(26.926)	(19.230)
Observations	36,017	25,919	28,386
Number of pid	15,998	13,989	14,571
Log-Likelihood:	-8377	-6108	-7001
Chi-squared	656	481	568.6
Prob Wald:	0.000	0.000	0.000

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Control variables are the same as those used in Table 2.