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Does the Digital Divide Affect Farmers' Motivation for Agricultural Practices? Evidence from China

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ABSTRACT

This study examines the impact of the three-tier digital divide (access, usage, outcome) on Chinese farmers' agricultural behavioral initiative using 2022 China Family Panel Studies data. Multivariate regression analyses reveal significant negative effects: access divide ($\beta = -2.39$, $p < 0.05$), usage divide ($\beta = -3.23$, $p < 0.01$), and outcome divide ($\beta = -2.62$, $p < 0.01$), with the usage divide showing the strongest inhibitory effect. Endogeneity-adjusted models confirm robustness (access: $\beta = -11,178.4$, $p < 0.1$; usage: $\beta = -18,935.8$, $p < 0.01$; outcome: $\beta = -6,451.3$, $p = 0.0736$). Mechanism analysis identifies class perception, information collection willingness, and risk preference as mediating factors. Heterogeneity analyses demonstrate: 1) Age effects—usage divide uniquely impacts farmers under 45 ($\beta = 13,644.7$), while all divides affect older groups ($p < 0.01$); 2) Regional disparities—non-eastern regions exhibit stronger negative effects ($\beta = -7,004.3$ to -13,736.6, $p < 0.01$) compared to eastern areas; 3) Gender differences—males are more affected by access and usage gaps ($\beta = -7,270.4$ to -11,545.6), whereas females show greater susceptibility to usage and outcome divides ($\beta = -17,023.0$ to -5,978.7, $p < 0.05$). These findings contribute to digital divide research by empirically validating the outcome divide's behavioral implications and providing policy insights for digital inclusion strategies in rural agriculture. At the same time, these

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findings also provide some references for further research on the relationship between the digital divide and farmers' income, regional agricultural economy in developing countries.

Keywords: Access Divide; Usage Divide; Outcome Divide; Information Acquisition Efficiency

1. Introduction

With the deepening of the digital economy, China has entered a rapidly developing era of internet information. Differences in internet access levels and application efficiency have significantly impacted people's lives. On November 21, 2024, the China Academy of Cyberspace Studies released the *China Internet Development Report 2024 and the World Internet Development Report 2024*. According to these reports, as of June 2024, the number of internet users in China had reached 1.1 billion, an increase of 7.42 million compared to December 2023, with an internet penetration rate of 78%. The rapid development of internet information technology has brought convenience to people's lives. However, differences in internet access levels, usage frequency, and information acquisition efficiency also affect social interactions and mental well-being. In recent years, with the continuous improvement of digital infrastructure in rural areas, both the scale of internet access and the level of application among the rural population have significantly increased [1].

According to the 53rd Statistical Report on China's Internet Development, the internet penetration rate in rural areas of China is expected to reach 68.5% by the end of 2024. This is also highlighted in the 2024 Key Tasks for Digital Rural Development. Additionally, the number of rural broadband access users will reach 200 million [2–4]. The continuous improvement of internet penetration has introduced new online social and entertainment opportunities for rural residents. It has also provided precise information retrieval channels for agricultural investment recommendations and everyday knowledge acquisition.

To some extent, this advancement is expected to enhance rural residents' enthusiasm for agricultural activities [5]. Due to the uneven pace and extent of digital technology development, there are differences in internet access and usage among residents of different countries or regions. These disparities can lead to inconveniences in areas such as information retrieval, daily life, and work. Similarly, these differences can have adverse effects on their agricultural work, and this gap in internet access or usage is referred to as the "digital divide." The concept of the digital divide originally referred to the gap between different groups in terms of access to internet resources, specifically whether individuals are able to access the internet or digital technologies [6]. This level of the digital divide is called the digital access divide, which is the most basic form of the digital divide. The digital usage divide, or the second level of the digital divide, refers to the unequal access to internet resources caused by differences in individuals' skills or frequency of internet use. The third-level digital divide is a deeper impact that evolves from the digital usage divide, referring to the differences in individuals' psychological perceptions of internet technology.

The existence of the digital divide directly reduces farmers' abilities to retrieve information, make informed decisions, and access resources. The decline in these three capabilities may indirectly lower farmers' agricultural activity engagement. This is because the negative effects of the digital divide permeate various stages, such as production and sales [7]. In the sales process, the digital divide limits the channels or methods available for selling agricultural products. This prevents farmers from fully utilizing online platforms such as e-commerce and online marketplaces, thereby restricting income growth. In the long term, this effect of the digital divide may hinder the increase in farmers' agricultural activity engagement. In the current context of improving internet coverage and application levels, research on the impact of the digital divide on farmers' enthusiasm for agricultural activities and the underlying mechanisms has become an important topic with significant theoretical value and practical implications.

As a country with rapid internet development, China has also witnessed a digital divide caused by re-

gional and economic disparities. This divide is directly reflected in the current issue of the digital gap. Technological innovation plays an increasingly important role in modern agricultural production and development [1]. The promotion and application of internet technology can reduce information asymmetry. It provides farmers with opportunities to access real-time and convenient production information, significantly boosting their agricultural motivation. In the long term, this behavior can greatly drive the reform of the national agricultural production system and lay a foundation for agricultural policy and technological transformations. Therefore, exploring the impact of the digital divide on farmers' agricultural behavior holds both academic and practical significance and deserves further investigation. However, existing research on the impact of the digital divide on farmers' agricultural engagement remains limited. Most current studies used composite indicators such as the Digital Divide Index to measure the degree of digital divide experienced by farmers (These indicators are typically constructed by standardizing responses to multiple questions using methods like the entropy weight method, ultimately forming a comprehensive index that reflects the overall level of the digital divide). While this approach effectively captures the general impact of the digital divide, it fails to examine the influence and underlying mechanisms of each individual dimension in depth. This study adopts a three-tier analytical framework—digital access divide, digital usage divide, and digital outcome divide, which fills a gap in existing research. It enables a detailed investigation into the impacts and mechanisms of each layer of the digital divide, allowing for the formulation of targeted policy recommendations to mitigate their respective negative effects. Furthermore, while much of the existing literature focuses on developed countries, this study addresses the underexplored context of developing countries. By examining how the digital divide affects farmers' agricultural engagement in China, it offers valuable insights and policy references for alleviating the digital divide's adverse effects on farmers in other developing nations. The logical framework of this study is illustrated as follows (**Figure 1**).

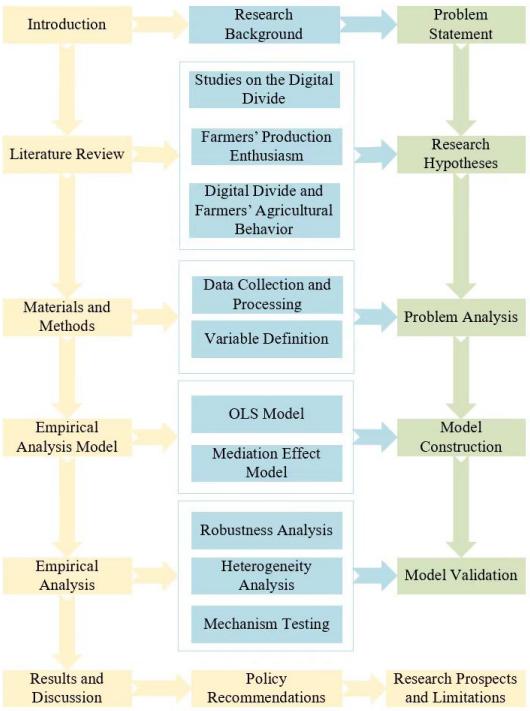

Figure 1. Framework of This Study.

2. Literature Review

2.1. Literature Review on the Digital Divide

The concept of the digital divide dates back to a U.S. government report on digital technologies in the late 20th century. Since then, the meaning of the term has been further refined with the ongoing development of the times. A widely accepted classification of the digital divide in academic circles is the "Access Gap - Usage Gap - Outcome Gap" framework, used by researchers such as Yastıbaş and Baturay [8]. Early research primarily focused on the first and second levels of the digital divide, namely the "Access Gap" and the "Usage Gap," resulting in relatively abundant research findings. The "Access Gap" refers to the inequality in internet access and the ability to obtain digital information resources among different countries, regions, or social groups. It is the primary form of the digital divide [8].

Building upon this, as internet development continues to advance, scholars have recognized that there are

significant differences in the extent and frequency of internet use among people within the same country or region. This inequality in usage levels or information acquisition capabilities, based on established internet access levels, is referred to as the second-level digital divide, or the "Usage Gap" [9]. In recent years, many scholars have gradually expanded their research to the level of "impact effects," focusing on the consequences of differences in internet access and usage. Studies have found that the long-term effects and impacts of internet access and usage are far more severe than the issues and disparities they create. This effect is known as the third-level digital divide, or the "Outcome Gap" [10]. The "Outcome Gap" is essentially the result of the "Usage Gap." It refers to the changes in people's perception, values, and behavior norms caused by differences in internet usage levels. It represents a subjective evaluation of internet usage levels [11].

Research has shown that the three levels of the digital divide are not isolated from one another; rather, they collectively impact residents through a chain effect [12]. The effects of the digital divide can be analyzed from both subjective and objective levels. Objectively, the digital divide negatively impacts residents in various areas, including social welfare, employment, income, asset levels, and education. Subjectively, it affects residents' well-being, satisfaction, and health, leading to issues such as depression and negative emotions [13,14].

2.2. Literature Review on the Enthusiasm of Farmers for Productive Activities

Currently, academic research on farmers' production activities is mainly concentrated in developed countries, as these countries began modernizing agricultural machinery early and have a much higher level of internet application and penetration compared to developing nations. Studies have found that developed countries have long recognized the important value of internet technology in improving agricultural production efficiency. For example, the United States has introduced policies to promote the application of 5G technology in agriculture [15]. In addition, the UK has established experimental projects to explore the integration of 5G technology in agricultural production. What is more, some countries are working to incorporate internet technology into future agricultural development frameworks. Thailand, in particular, has made significant progress in this area. To promote the integration of agriculture and digital technology, Thailand's agricultural promotion department established a dedicated unit, incorporating internet development into the country's future agricultural development framework [16]. As of now, Thailand has achieved several goals, including the promotion of digital infrastructure in rural areas, the transition from traditional government to digital government, and providing subsidies to farmers for internet technology updates and iterations.

In addition, existing studies have shown that digital technology can effectively improve efficiency in agricultural and pastoral production. Researchers have found that technological progress contributes to higher economic benefits. This is mainly because it helps reduce energy use and production costs, thereby increasing agricultural productivity. Improved productivity is often accompanied by greater profit margins, which ultimately enhances farmers' income levels. However, the existence of the digital divide may hinder the integration of digital technology into agricultural production. It can obstruct the application of advanced agricultural processing technologies, leading to reduced productivity and compressed profit margins, which in turn limits the growth of farmers' income [17]. Moreover, Oztuna Taner (2024) pointed out that the comprehensive benefits of modern agriculture can be improved by enhancing the level of technology used in production. These benefits include not only economic gains but also environmental outcomes [18–20]. Researchers have also found that the application of digital technology in agriculture can further improve the quality of dairy products [21,22].

These findings further demonstrate the important role of digital technology in agricultural production and farmers' agricultural motivation. This also indirectly reflects the negative impact of the digital divide on the improvement of overall agricultural efficiency. Specific research findings indicate that internet usage can promote farmers' non-agricultural employment, land transfer, and risk investment. At the same time, Liu et al. found through micro-level empirical research that

smartphones and internet access help farmers obtain more information, thereby optimizing the rationality of their agricultural decisions [23]. Mekuria, F et al. believe that in developed countries like Switzerland, the internet can significantly reduce the knowledge gap among farmers, thereby promoting the development of social networks [24].

In conclusion, existing national policies and academic research clearly demonstrate that the development of the internet holds significant value and importance for agricultural development and the improvement of farmers' capabilities in developed countries.

2.3. The Digital Divide and Farmers' Agricultural Behavior

Existing research on the digital divide and farmers' production activities mainly focuses on developed countries. These studies typically categorize the digital divide into digital access gaps and digital usage gaps, while overlooking the objective existence of the third-level digital divide—the digital outcome gap. This leads to two direct consequences: First, developing countries, represented by China, cannot directly apply the research findings from developed nations due to unique national circumstances. As a result, there is a lack of literature and research references when promoting internet development and agricultural system innovation. Second, in recent years, with the further development of the internet, the digital outcome gap has been recognized by researchers. This gap describes the potential consequences of the long-standing second-level digital divide—the digital usage gap—specifically, the psychological perception of the importance of internet use by individuals [10,25]. It is crucial to the future integration and development of the agricultural system and internet technology, making it of significant practical importance and research necessity.

At present, researchers mainly measure farmers' agricultural motivation by calculating the sum of primary agricultural expenditures and other agricultural-related expenditures. Primary agricultural expenditures refer to the total amount spent on crop production—such as seeds and fertilizers—and on livestock farming—such as feed—during the past year. This indicator reflects the level of investment in core agricultural activities over a one-year period. Other agricultural-related expenditures refer to additional investments made by farmers to increase income or reduce risks. These include spending on agricultural insurance, greenhouse construction, and similar activities. The sum of primary and other agricultural expenditures provides a comprehensive assessment of rural residents' agricultural input levels over the past year. A higher level of input indicates stronger agricultural motivation, while a lower level suggests weaker motivation.

The digital divide and farmers' agricultural motivation are two areas that rarely intersect in existing research. As a result, studies focusing on the impact of the digital divide on farmers' agricultural motivation remain limited. Current literature mostly concentrates on the relationship between the digital divide and farmers' income. For example, Liu (2023) argued that the digital divide has a negative effect on farmers' income. However, focusing solely on income cannot fully capture the influence of the digital divide on agricultural motivation. This is because agricultural motivation involves not only income-related factors but also farmers' perceptions of and responses to risk. Therefore, a deeper examination of how the digital divide affects agricultural motivation can reveal not only its impact on production inputs but also its influence on the deeper psychological dimensions of Chinese farmers [26].

This study takes China as an example and adopts the three-tier research framework of "Access —Usage — Outcome Gap" to conduct a detailed micro-level study of farmers' agricultural behavior and enthusiasm. Second, the depth of the research framework. Instead of applying the commonly used two-level framework—access and usage divides—or relying on a single composite index, this study adopts a three-level structure: access divide, usage divide, and outcome divide. This approach has two advantages. It clearly reveals the distinct impacts of each level of the digital divide on farmers' agricultural motivation. It also offers more targeted policy suggestions across different dimensions, including access, usage, and outcomes. This study presents three main contributions that distinguish it from existing research. First, the specificity of the research subject.

This study focuses on the impact of the digital divide on the agricultural motivation of rural residents in China. As the largest developing country, China's rural population is significantly affected by the dual urban–rural structure, which leads to unequal resource distribution. These structural disparities make the influence of the digital divide more complex for Chinese farmers. Therefore, using rural residents in China as the research subject holds particular academic relevance. Third, an in-depth analysis of the underlying mechanisms. This study explores the mechanisms through which each level of the digital divide influences agricultural motivation. The findings indicate that willingness to collect information, risk preferences, and perceived social status mediate the effects of different levels of the digital divide. This layered mechanism analysis helps clarify the distinct pathways through which each digital divide level operates, offering more precise strategies to mitigate its adverse effects.

2.4. Research Hypotheses

The digital divide refers to the inequities arising from differences among individuals in terms of internet access, usage, and outcomes. Based on studies by domestic and international scholars, this paper categorizes the digital divide into three levels: access divide, usage divide, and outcome divide. In recent years, with the continuous advancement of internet technology, rural residents in China have also benefited from increased convenience in their daily lives. First, online agricultural information platforms, such as real-time weather forecasts and agricultural product price comparison platforms, have significantly reduced the time and financial costs for farmers in obtaining and filtering information. At the same time, these platforms objectively provide farmers with a wealth of agricultural production information as a reference [23,27]. Furthermore, these online platforms have further reduced the information asymmetry between Chinese farmers and the agricultural product market, thereby enhancing the specificity and efficiency of communication. Finally, internet usage also helps rural residents expand their existing social networks by strengthening connections with others through social media and online communities. This facilitates the exchange of agricultural production experiences and broadens potential agricultural markets. Currently, some scholars have proposed that internet usage contributes to improving the economic benefits of agricultural production and enhancing farmers' production enthusiasm. For example, MacPherson et al. suggested that the development of the digital economy can significantly improve the efficiency of agricultural resource allocation [28]. Therefore, this paper proposes the hypothesis: H1: The digital divide will significantly reduce farmers' enthusiasm for agricultural activities.

Digital access divide and farmers' Agricultural Behavior. The access gap in the digital divide refers to inequalities arising from whether individuals have internet access. In rural China, the internet serves as a crucial medium in modern agricultural production, playing an indispensable role in various stages such as production, management, and sales [8]. Internet access not only enhances agricultural productivity and reduces operational costs but also expands market opportunities for agricultural products. Therefore, this study proposes the hypothesis:

H1a. *The access divide of the digital divide significantly reduces farmers' agricultural motivation.*

Digital usage divide and farmers' Agricultural Behavior. The usage divide refers to the inequality arising from differences in internet usage frequency. Modern agriculture is characterized by immediacy and multidimensionality, which places higher demands on the quality and speed of information access. Wen (2023) argues that the existence of the digital divide hinders the expansion of agricultural production scale and limits farmers' access to efficient digital production tools, thereby affecting their productivity. This may reduce farmers' enthusiasm for engaging in agricultural activities [29]. Based on this, the following hypothesis is proposed:

H1b. *The existence of the digital usage gap will reduce farmers' enthusiasm for agricultural activities.*

Digital outcome divide and farmers' Agricultural Behavior. The outcome divide of the digital divide refers to the differences in individuals' perceptions, values, and behavioral norms caused by varying levels of internet usage. The existence of this divide may mislead farm-

ers with false information or cause them to miss out on important production opportunities, thereby reducing their enthusiasm for engaging in agricultural activities. Accordingly, this study proposes Hypothesis H1c: The existence of the digital outcome divide negatively impacts farmers' enthusiasm for agricultural activities.

The Mediating role of information collection willingness. Willingness to gather information refers to the resources and advantages individuals or groups acquire through social networks in the production process. Due to the relatively low overall education levels and individual competencies among China's rural residents, they often remain at a disadvantage in terms of information acquisition efficiency and quality. Additionally, Chinese farmers generally have weaker risk resilience in agricultural production, making their engagement in farming activities highly susceptible to fluctuations in economic returns. The existence of the digital divide significantly restricts the speed and quality of information access in various agricultural processes, including production, management, and sales. This, in turn, reduces the economic benefits they can obtain, ultimately weakening their willingness to gather information [30]. Yang et al. explored the impact of information acquisition and declining economic benefits on the scalability of agricultural operations, highlighting that delays in obtaining information and reduced economic returns can lead to a decline in farmers' enthusiasm for agricultural activities [31].Based on the above, this study proposes the following hypothesis:

H2. *At every level, the digital divide restricts farmers' enthusiasm for agricultural activities by reducing their willingness to gather information.*

The Mediating role of risk preference. Risk preference refers to an individual's willingness to take on risks in their production and business activities. The digital divide hinders farmers from obtaining up-to-date market information, which prevents them from adjusting their production and business activities in response to changes in market demand and supply [32]. As a result, farmers may make poor decisions, such as taking on excessive risks in pursuit of higher economic returns. This study hypothesizes that an increase in risk preference mediates the relationship between the digital divide and farmers' agricultural behavioral motivation. Accordingly, Hypothesis 3 is proposed:

H3. *The digital divide reduces farmers' agricultural behavioral motivation by increasing their level of risk preference.*

The Mediating role of perceived social class. Perceived social class refers to an individual's evaluation of their own position within the broader social environment. The existence of the digital divide may prevent farmers from interacting with higher social groups via social media. As a result, they may develop an inflated perception of their own social class [27]. This could reduce their willingness to engage in agricultural production and management, as they may prefer to pursue occupations associated with higher social status. Based on this, the following hypothesis is proposed:

H4. *The digital divide reduces farmers' motivation to engage in agricultural activities by increasing their perceived social class.*

3. Materials and Methods

3.1. Data

The data for this study is derived from the 2022 China Family Panel Studies (CFPS) project. This project is a national, comprehensive, and large-scale research initiative launched by the China Social Science Survey Center (ISSS) at Peking University. It tracks and collects data at the individual, family, and community levels, reflecting changes in various fields such as Chinese society, economy, and agriculture, thereby ensuring that the data is relatively representative. The CFPS 2022 employed implicit stratified sampling and multistage equal probability sampling methods. Specifically, the sampling process consists of three stages. In the first stage, administrative districts or counties are selected as the primary sampling units (PSU). In the second stage, administrative villages or neighborhood committees within the selected areas are chosen as the secondary sampling units (SSU). In the third stage, a sampling frame is built using the map-address method. Then, households are selected using systematic sampling with a random starting point. This ensures the re-

liability of the sampling results. This study covers 25 provinces, municipalities, and autonomous regions in China, excluding Hong Kong, Macao, Taiwan, Xinjiang, Qinghai, Inner Mongolia, Ningxia, and Hainan, accounting for approximately 95% of the total population. Given the rapid urbanization in China, CFPS adopts an integrated sampling approach rather than separately sampling urban and rural areas. Data are collected at three levels: community-level data from local residents' or village committees, household-level data from sampled families, and individual-level data from respondents. Before conducting the empirical analysis, the author performed necessary data cleaning. To ensure the robustness and reliability of the study, samples that did not fully meet the criteria in CFPS2022 or lacked key variables, such as digital access divide, digital usage divide, digital outcome divide, and farmers' agricultural engagement, were excluded from this study. Ultimately, 3,080 valid data points were retained for analysis.

3.2. Definition of Variables

Dependent Variable. The dependent variable in this study is farmers' agricultural motivation. Based on the CFPS survey, two questions are used to construct the variable *agricultural activity*: "How much did you invest in primary agricultural production activities over the past year?" and "How much did you invest in other agricultural activities over the past year?" The values from these two questions are summed to form a single indicator. This composite variable is used to evaluate the level of farmers' motivation in agricultural activities.

Independent variables: The independent variable in this study is the digital divide, which is divided into three levels: digital access divide, digital usage divide, and digital outcome divide, based on the research of Khamtavee, T.[21].

Firstly, the digital access divide is constructed based on the questions in the CFPS survey, "Do you access the internet via mobile?" and "Do you access the internet via computer?" The variable "digital access divide" is categorized as follows: if the answer to at least one of these questions is "Yes," the individual is considered not to have a digital access divide. If both answers are "No," the individual is considered to have a digital access divide.

Secondly, for the group without a digital access divide, this study constructs the "digital usage divide" using factor analysis based on responses to the following CFPS survey questions: "Do you play online games?", "Do you engage in online learning?", "Do you watch short videos?", and "Do you shop online?". A higher score on this factor indicates a greater level of digital usage divide experienced by the farmer.

Finally, for the digital outcome divide, this study selects questions such as "How important do you think the internet is for work?", "How important do you think the internet is for leisure and entertainment?", "How important do you think the internet is for staying in touch with family and friends?", "How important do you think the internet is for learning?", and "How important do you think the internet is for daily life?". The answers to these questions are assigned scores from 1 to 5, ranging from "Very Important" to "Not Important." Factor analysis is then used to construct a unified evaluation variable called "digital outcome divide," with higher scores indicating a higher level of digital outcome divide experienced by the farmer.

Control variables: This study refers to the research of Jayne and Anno Si, and selects six control variables that are highly relevant to the research content: gender, education, marital status, income, innovation, and region[33,34]. Gender, education, marital status, income, and region are closely related to farmers' agricultural engagement, as they influence behavior at the individual, household, and regional levels. Innovation is also included as a control variable, considering its entrepreneurial effect. Existing studies suggest that digital technology not only lowers the threshold for innovation and enhances farmers' production enthusiasm, but also expands social networks and accumulates social capital, thereby promoting both regional and individual economic development. Therefore, farmers' willingness to innovate is strongly associated with their agricultural engagement.

Mediator variables: Based on Liu's research. The mediator variables in this study are information collection willingness, risk preference, and personal class perception. Information collection willingness is assessed

through the question "What is your monthly postal and telecommunications fee?" in the survey. Risk preference is evaluated based on the question "Do you hold any financial products?" in the survey. Personal class perception is measured by the question "How do you perceive your social status?" in the survey[35].

Instrumental variable: Referring to the study by Lu et al. (2023), this paper selects the average level of the digital divide among individuals of the same age within the respondent's village as an instrumental variable. This approach is used to conduct an endogeneity test, aiming to ensure the robustness of the research findings and to reduce the impact of endogeneity[36,37]. The descriptive statistics of this study are shown in **Table 1**.

Table 1. Descriptive Statistics Analysis Results.

Item	Opt	Cnt	N	Pet	Var
Dependent Variable					
Agricultural activity	Agricultural activity Input	/	3080	/	
Primary Agricultural Input?	**Outcome and quantity**		3080		
Others agricultural input?	**Outcome and quantity**		3080		
Independent Variable					
Level of digital divide					
Digital access divide	Exists digital access divide	484	3080	15.71	0.1325
	No digital access divide	2596	3080	84.29	0.1325
Digital usage divide					
Whether engaged in online gaming	No	1462	2007	72.85	0.4449
	YES	545	2007	27.15	0.4449
Engage in online learning	NO	1551	2007	77.28	0.4191
	YES	156	2007	22.72	0.4191
Use short videos	NO	229	2007	11.41	0.3180
	YES	1778	2007	88.59	0.3180
Engage in online shopping	NO	1057	2007	52.67	0.4994
	YES	950	2007	47.33	0.4994
Digital outcome divide					
The importance of the internet for work	Very important	682	2007	33.98	1.317
	Important	380	2007	18.93	1.317
	Neither important nor unimportant	564	2007	28.10	1.317
	Unimportant	165	2007	8.22	1.317
	Very unimportant	216	2007	1076	1.317
The importance of the internet for leisure and entertainment	Very important	500	2007	24.91	1.1647
	Important	454	2007	22.62	1.1647
	Neither important nor unimportant	693	2007	34.53	1.1647
	Unimportant	235	2007	11.71	1.1647
	Very unimportant	125	2007	6.23	1.1647
The importance of the internet for socializing	Very important	1182	2007	58.89	0.9312
	Important	481	2007	23.97	0.9312
	Neither important nor unimportant	242	2007	12.06	0.9312
	Unimportant	71	2007	3.54	0.9312
	Very unimportant	31	2007	1.54	0.9312
The importance of the internet for learning	Very important	693	2007	34.53	1.1994
	Important	498	2007	24.81	1.1994
	Neither important nor unimportant	519	2007	25.86	1.1994
	Unimportant	170	2007	8.47	1.1994
	Very unimportant	127	2007	6.33	1.1994
The importance of the internet for daily life	Very important	711	2007	35.43	1.3308
	Important	385	2007	19.18	1.3308
	Neither important nor unimportant	473	2007	23.57	1.3308
	Unimportant	246	2007	12.26	1.3308
	Very unimportant	192	2007	9.57	1.3308

Table 1. *Cont.*

Item	Opt	Cnt	N	Pet	Var
Control variables					
Gen	male	1587	3080	51.53	0.4998
	female	1493	3080	48.47	0.4998
Edu	Associate degree or higher	111	3080	3.60	0.1864
	Associate degree or lower	2969	3080	96.40	0.1864
Mar	Unmarried	487	3080	15.81	0.3649
	Married	2593	3080	84.19	0.3649
Inc	Low-income households (below the average)	1945	3080	63.15	0.4825
	High-income households (below the average)	1135	3080	36.85	0.4825
Inn	Possesses an innovative mindset	1222	3080	39.68	0.2394
	NO innovative mindset	1858	3080	60.32	0.2394
Region	East	933	3080	30.29	0.8841
	Central	514	3080	16.69	0.8841
	West	1633	3080	53.02	0.8841

Item	Cnt	Avg	Med	Min	Max	SD	Kurt	Skew
Age	3080	42.6081	42	9	96	19.2790	2.1813	01867
Digital divide in usage	2007	0.9403	0.9030	0	1.7053	0.4260	2.5497	0.3142
Digital divide in outcome	2007	3.0757	3.0024	1.3568	6.7839	1.2026	2.6064	0.4109
Dependent Variable								
Agri_activity enthusiasm	3080	25980.72	10300	160	1200000	64112.41	191.7297	12.0813

3.3. Research Methods

This study uses the OLS (Ordinary Least Squares) model for data analysis, as it allows researchers to examine the effect of one independent variable on the dependent variable while controlling for the effects of other variables. This characteristic aligns with the research needs of modern agricultural behavior motivation and effectively reflects the impact of the digital divide on farmers' agricultural behavior motivation [25]. Based on the methodology of Wang et al. (2025) [38], the specific model used in this paper is as follows:

$$\text{Agricultural activity} = \alpha_0 + \alpha_n \text{digital divide} + \alpha_{2n} X + \Sigma_i \quad (1)$$

In Equation (1), agricultural activity is the dependent variable, representing the level of agricultural behavior enthusiasm among Chinese farmers. Digital divide is the independent variable, referring to the level of the digital divide experienced by farmers, which can be divided into three levels: access gap, usage gap, and outcome gap. *X* represents control variables such as age, marital status, gender, education, income, innovation, and region. α_0 denotes the constant term, α_n and α_{2n} represent the core parameters to be estimated, and Σ_i refers to the random disturbance term.

Mediation effect model. To further explore the mechanism through which the level of the digital divide affects the mental health of rural residents in China, this study draws on the research of Yuan. Based on Equation (1), a stepwise regression method is employed to construct the model , as follows:

$$\text{Agricultural activity} = \beta_0 + \beta_n \text{Information Collection Cost} + \beta_{2n} X + \Sigma_i \quad (2)$$

$$\text{Agricultural activity} = \gamma_0 + \gamma_n \text{Risk Preference} + \gamma_{2n} X + \Sigma_i \quad (3)$$

$$\text{Agricultural activity} = \Sigma_0 + \Sigma_n \text{Perceived Social Class} + \Sigma_{2n} X + \Sigma_i \quad (4)$$

$$\text{Agricultural activity} = \theta_n \text{Information Collection Cost} + \theta_{2n} \text{Rist Preference} + \theta_{3n} \text{Perceived Social Class} + \theta_{4n} X + \Sigma_i \quad (5)$$

In Equation (2) (3) (4) (5), Agricultural activity represents the agricultural activity enthusiasm level of Chinese farmers. **Information collection cost**, **risk preference**, and **Perceived social class** represent the three mediator variables, respectively. **X** denotes a series of control variables. β_0, γ_0, and Σ_0 are constant terms, while β_n, γ_n, and Σ_n are the estimated coefficients for the mediator variables. β_{2n}, γ_{2n}, and Σ_{2n} represent the coefficients for the control variables. Σ_i is the random disturbance term.

β_n, β_{2n}, γ_n, and γ_{2n} are the parameters to be estimated. In Equation (4), Agricultural activity represents the level of agricultural engagement among Chinese farmers. Σ_0 is the constant term, while Σ_n and Σ_{2n} are the parameters to be estimated.

Compared to Equation (1), Equations (2), (3), and (4) introduce the mediator variables Information Collection Cost, Risk Preference, and Perceived Social Class as dependent variables, which allow for examining the influence of the three levels of the digital divide on the Perceived Social Class of farmers. If the regression coefficients in Equation (2), (3), or (4) are statistically significant, and the regression result in Equation (5) is also significant with a reduced coefficient, this indicates the presence of a mediating effect.

4. Results

4.1. Model Testing

To ensure the validity of the Ordinary Least Squares (OLS) regression model and the robustness of the empirical results, this study conducted tests for multicollinearity and autocorrelation prior to the main analysis. The diagnostic results are presented in **Table 2**. **Table 2**(**A**) presents the results of the multicollinearity test using Variance Inflation Factors (VIF). A VIF value closer to 1 indicates a lower risk of multicollinearity. The VIFs for Digital Access Divide, Digital Divide in Usage, and Digital Divide in Outcome are 1.11, 1.32, and 1.04, respectively, with an average VIF of 1.25. These results suggest that multicollinearity is not a serious concern in the model, indicating the appropriateness of the variable selection. Parts (**B**), (**C**), and (**D**) of **Table 2** present the correlation matrices for Digital Access Divide, Digital Divide in Usage, and Digital Divide in Outcome, respectively. These matrices illustrate the correlations between each dimension of the digital divide and other independent variables. Correlation coefficients closer to 1 indicate more severe autocorrelation. The results show that most correlations are either negligible or weak, suggesting minimal multicollinearity. Therefore, the model specification is appropriate and the estimation results are considered reliable.

Table 2. Model Testing.

(A) Multicollinearity Test (VIF)						
	Digital Access Divide		**Digital Usage Divide**		**Digital Outcome Divide**	
Var	**VIF**	**1/VIF**	**VIF**	**1/VIF**	**VIF**	**1/VIF**
Digital Divide in Access	1.11	0.90				
Digital Divide in Usage			1.32	0.75		
Digital Divide in Outcome					1.04	0.96
Gen	1.01	0.99	1.02	0.97	1.02	0.98
Edu	1.03	0.96	1.05	0.95	1.05	0.94
Mar	1.31	0.76	1.36	0.73	1.34	0.74
Age	1.29	0.77	1.62	0.51	1.79	0.55
Inn	1.20	0.83	1.68	0.59	1.67	0.59
Inc	1.03	0.97	1.05	0.95	1.05	0.95

Table 2. *Cont.*

(A) Multicollinearity Test (VIF)								
	Digital Access Divide		**Digital Usage Divide**		**Digital Outcome Divide**			
Var	**VIF**	**1/VIF**	**VIF**	**1/VIF**	**VIF**	**1/VIF**		
Region	1.02	0.98	1.03	0.97	1.03	0.97		
Mean VIF	1.12		1.30		1.25			
(B) Autocorrelation Test Results (corr): Digital Divide in Access								
Var	**Digital Divide in Usage**	**Gen**	**Edu**	**Mar**	**Age**	**Inn**	**Inc**	**Region**
Digital Divide in Usage	1.0000							
Gen	-0.0007	1.0000						
Edu	-0.0739	0.0098	1.0000					
Mar	0.1553	-0.0820	-0.0976	1.0000				
Age	0.1301	-0.0204	-0.0947	0.4465	1.0000			
Inn	0.2954	0.0031	-0.1070	0.2660	0.2594	1.0000		
Inc	-0.0432	0.0070	0.1123	-0.0157	-0.0567	-0.0954	1.0000	
Region	0.0404	0.0274	-0.0123	-0.0577	-0.0551	-0.0111	-0.0845	1.0000
(C) Autocorrelation Test Results (corr): Digital Divide in Usage								
Var	**Digital Divide in Usage**	**Gen**	**Edu**	**Mar**	**Age**	**Inn**	**Inc**	**Region**
Digital Divide in Usage	1.0000							
Gen	-0.0441	1.0000						
Edu	-0.1405	-0.0005	1.0000					
Mar	0.3231	-0.0751	-0.0650	1.0000				
Age	0.4460	0.0397	-0.0517	0.4724	1.0000			
Inn	0.3652	-0.0263	-0.1498	0.3897	0.6013	1.0000		
Inc	-0.1055	0.0152	0.1165	0.0082	-0.0534	-0.1357	1.0000	
Region	-0.0329	0.0459	-0.0075	-0.0874	-0.1040	-0.0265	-0.0873	1.0000
(D) Autocorrelation Test Results (corr): Digital Divide in Outcome								
Var	**Digital Divide in Outcome**	**Gen**	**Edu**	**Mar**	**Age**	**Inn**	**Inc**	**Region**
Digital Divide in Outcome	1.0000							
Gen	0.0206	1.0000						
Edu	-0.1356	-0.0005	1.000					
Mar	0.0286	-0.0751	-0.0650	1.0000				
Age	-0.0573	0.0397	-0.0517	0.4724	1.0000			
Inn	-0.0244	-0.0263	-0.1498	0.3897	0.6013	1.0000		
Inc	-0.1052	0.0152	0.1165	0.0082	-0.0534	-0.1357	1.0000	
Region	0.0032	0.0459	-0.0075	-0.0874	-0.1040	-0.0265	-0.0873	1.0000

4.2. Baseline Regression

As outlined in the previous section, this study employs the OLS model to analyze the impact of different levels of the digital divide on farmers' agricultural activity enthusiasm. **Table 3** presents the effects of various levels of the digital divide on Chinese farmers' agricultural activity enthusiasm, with results shown in columns (1) to (3).

Table 3. Baseline Regression Results.

Var	(1)		(2)		(3)	
	farmers' agricultural motivation					
Digital Divide in Access	-7877.5**	(-2.39)				
Digital Divide in Usage			-14458.2***	(-3.23)		
Digital Divide in Outcome					-3686.3***	(-2.62)
Gen	-2358.6	(-1.03)	-2133.0	(-0.63)	-1307.9	(-0.39)
Edu	-8430.6	(-1.36)	-10102.3	(-1.34)	-10077.7	(-1.33)
Mar	4935.7	(1.38)	9547.3**	(2.10)	8552.6*	(1.89)
Age	-155.1**	(-2.31)	-301.7**	(-2.10)	-449.5***	(-3.24)
Inn	13475.8***	(5.30)	20434.5***	(4.70)	18888.7***	(4.36)
Inc	17634.5***	(7.37)	19435.9***	(5.60)	19312.6***	(5.55)
Geo	-4860.9***	(-3.75)	-6011.0***	(-3.19)	-6135.8***	(-3.25)
Cnt	3080		2007		2007	
R^2	0.338		0.391		0.374	

Notes: *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively;
The t-statistic is shown in parentheses;
Control variables have been included in the regression.

As indicated in **Table 3**, the effect of the digital access divide on farmers' agricultural activity enthusiasm is significantly negative at the 5% level. The impact of the digital usage divide is significantly negative at the 1% level. This suggests that when rural residents face limitations in internet access or have lower digital skills, their agricultural activity enthusiasm tends to decline. Additionally, the effect of the digital outcome divide is significantly negative at the 1% level, indicating that as the adverse consequences of internet usage intensify, rural residents' agricultural activity enthusiasm is further negatively affected.

Therefore, hypothesis H1 is supported, along with sub-hypotheses H1a, H1b, and H1c.

4.3. Robustness Check

To ensure the robustness and reliability of the research findings, this study further processes the data by replacing the dependent variable, conducting endogeneity tests, removing extreme values, and replacing control variables. The specific results are presented in **Table 4**.

Robustness Check 1: Replacing the Dependent Variable. Specifically, the dependent variable—Agricultural activity—is replaced with annual agricultural production investment, and the analysis is conducted using the OLS model. As shown in **Table 4**, after replacing the dependent variable, the three levels of the digital divide continue to have a significantly negative impact on farmers' agricultural production enthusiasm, consistent with the baseline regression results, indicating that the conclusions are robust.

Robustness Check 2: Endogeneity Test. When examining the impact of the digital divide on agricultural behavior enthusiasm among rural residents in China, researchers must carefully address endogeneity issues to avoid systematic bias in the results. Common endogeneity issues include omitted variable problems, measurement error issues, and bidirectional causality. This study has already incorporated as many control variables as possible to minimize the impact of omitted variables and measurement errors on the results. Bidirectional causality refers to a situation where the independent variable not only influences the dependent variable, but the dependent variable also affects the independent variable. To ensure the robustness of the results, this study conducts an endogeneity test using the instrumental variable approach, with specific results shown in **Table 4**.

Drawing on the study by Lu et al. (2023) [36], the instrumental variable used in this study is the average level of the digital divide for respondents of the same age within the same province. This instrumental variable is closely related to an individual's digital divide level, but since it is based on the group average and has no direct causal relationship with the individual's agricultural

behavior enthusiasm, it satisfies the exogeneity require- ment for instrumental variables.

Table 4. Robustness Test.

Test 1: Replacement of the dependent variable	**(1)**	**(2)**	**(3)**
	annual agricultural production investment		
Digital Divide in Access	-6388.8** (-2.14)		
Digital Divide in Usage		-13792.4*** (-3.37)	
Digital Divide in Outcome			-3149.7** (-2.44)
Cnt	3080	2007	2007
R^2	0.297	0.354	0.329
Test 2: Endogeneity test	**(1)**	**(2)**	**(3)**
	farmers' agricultural motivation		
Digital Divide in Access	-11178.4* (-1.92)		
Digital Divide in Usage		-18935.8*** (-2.60)	
Digital Divide in Outcome			-6451.3*** (-3.08)
First-stage regression coefficients	0.949*** (37.83)	0.976*** (34.91)	0.990*** (40.73)
Hausman test value	0.47	0.61	3.20
P-value	0.4933	0.4346	0.0736
F-value	1431.08	1218.62	1658.8
Observations	3080	2007	2007
Robustness test 3: Removal of extreme values			
	farmers' agricultural motivation		
Digital divide in Access	-7584.0** (-2.16)		
Digital divide in Usage		-14989.3*** (-3.12)	
Digital divide in Outcome			-3856.8** (-2.46)
Cnt	2825	1834	1834
R^2	0.353	0.404	0.384
Robustness test 4: Replacing control variables			
	farmers' agricultural motivation		
Digital divide in Access	-8044.2** (-2.39)		
Digital divide in Usage		-14672.3*** (-3.28)	
Digital divide in Outcome			-3763.6*** (-2.67)
Cnt	3080	2007	2007
R^2	0.380	0.428	0.411

Notes: *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively;
The t-statistic is shown in parentheses;
Control variables have been included in the regression.

The regression coefficients for the three levels of the digital divide using the instrumental variables are all significant at the 1% level, indicating the validity of the instrumental variables. Additionally, the F-test values in the first stage are much greater than 0, passing the weak instrument test. After considering the endogeneity issue and introducing the instrumental variables, the regression results for the three levels of the digital divide on farmers' agricultural activity enthusiasm remain significantly negative. Therefore, the research conclusions remain robust.

Robustness Test 4: Trimming Extreme Values. To avoid the impact of extreme values on the research conclusions, this study trims the top 5% and bottom 5% of age samples, ensuring the reliability of the results, as shown in **Table 4**. After trimming the top and bottom 5% of the samples, the influence of extreme values on the reliability of the results is reduced. The regression results for the three levels of the digital divide on farmers' agricultural behavior enthusiasm remain significantly negative, which is consistent with the trend of the baseline regression results, confirming the robustness of the research conclusions.

Robustness Test 4: Replacing Control Variables. This study investigates the reliability of the conclusions by changing the control variables. Specifically, education is redefined (with values assigned as follows: below vocational school = 1, vocational/high school/technical school = 2, junior college = 3, undergraduate = 4, master's = 5, and doctoral = 6). Additionally, the central and western regions are merged into "non-eastern regions." The regression results are shown in **Table 4**. After changing the control variables, the effect of the digital access divide on farmers' agricultural activity enthusiasm remains significant at the 5% level, while both the digital usage divide and digital outcome divide are significantly negative at the 1% level, further confirming the robustness of the research conclusions.

In conclusion, whether through replacing the dependent variable, conducting endogeneity tests, eliminating extreme values, or replacing control variables, the research conclusions consistently align with the direction of the baseline regression. This further supports the reliability of the conclusion that the digital divide inhibits agricultural activity enthusiasm among Chinese farmers.

4.4. Heterogeneity Test

This section further explores the differences in the impact of the digital divide on the agricultural activity enthusiasm of Chinese farmers across different groups. The study is conducted from three aspects: age, gender, and region, in order to better understand the extent of the digital divide's impact on different groups of farmers, which is of great significance for future policy formulation. The specific results are shown in **Table 5**.

Heterogeneity analysis based on age. Referring to the study of Cui et al. (2024), this paper divides the sample into two groups: the youth group (under 45 years old) and the middle-aged and elderly group (45 years old and above) [39]. The results show that the agricultural activity enthusiasm of the middle-aged and elderly farmers is significantly negatively affected by all three levels of the digital divide, while in the youth group, the digital usage divide significantly impacts farmers' agricultural activity enthusiasm. This may be due to the lower knowledge learning ability and agricultural stress resistance of older rural residents. Therefore, their limited access to and use of the internet prevents them from actively utilizing the internet to improve agricultural production activities, thus reducing their agricultural activity enthusiasm.

Heterogeneity analysis based on gender. This paper examines the impact of the digital divide on male and female rural residents' agricultural activity enthusiasm separately. The results are as follows: The agricultural activity enthusiasm of male rural residents is significantly affected by the digital access and digital usage divides, while female residents are mainly affected by the digital usage and digital outcomes divides. This phenomenon may be because men in rural households bear more economic responsibility, which may lead to less investment in digital devices and internet services, as well as fewer opportunities for internet-related skill training. For female residents, their educational opportunities are relatively limited, which restricts their learning ability and results in weaker internet usage skills. Additionally, women often face more restrictions in market participation, such as information asymmetry and smaller

social networks, which may limit their opportunities to use internet technology to improve agricultural production and sales, thereby limiting their agricultural activity enthusiasm.

Table 5. Heterogeneity Analysis.

Var	**Age < 45**			**Age ≥ 45**		
	farmers' agricultural motivation					
	Digital divide					
Digital divide in Access	-6813.4 (-1.02)			-6656.7** (-2.26)		
Digital divide in Usage		-13644.7** (-2.45)			-18573.4** (-2.54)	
Digital divide in Outcome			-2965.3 (-1.43)			-5032.3*** (-3.01)
Cnt	1659	1369	1369	1421	638	638
R^2	0.333	0.367	0.339	0.438	0.525	0.564
	farmers' agricultural motivation					
Var	**Male**			**Female**		
	Digital divide					
Digital divide in Access	-7270.4* (-1.79)			-8211.8 (-1.57)		
Digital divide in Usage		-11545.6** (-2.19)			-17023.0** (-2.24)	
Digital divide in Outcome			-1937.6 (-1.19)			-5978.7** (-2.44)
Cnt	1587	1080	1080	1493	927	927
R^2	0.444	0.538	0.508	0.292	0.32	0.33
	farmers' agricultural motivation					
	Digital divide					
	Eastern Regions			**Non-Eastern Regions**		
Digital divide in Access	-8693.9 (-1.10)			-7004.3** (-2.11)		
Digital divide in Usage		-16232.1 (-1.60)			-13736.6*** (-2.97)	
Digital divide in Outcome			-2965.8 (-1.03)			-3778.3** (-2.46)
Cnt	933	634	634	2147	1373	1373
R^2	0.416	0.498	0.475	0.275	0.341	0.322

Notes: *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively;
The t-statistic is shown in parentheses;
Control variables have been included in the regression.

Heterogeneity analysis based on region. This paper divides regions into the eastern and non-eastern regions of China, with the non-eastern region consisting of the central and western regions. The results show that all three levels of the digital divide significantly negatively impact the agricultural activity enthusiasm of farmers in the non-eastern regions, while this impact is not significant for farmers in the eastern regions. This may be due to the differences in economic development and internet development between regions. The economic development speed in the eastern regions is relatively fast, digital infrastructure is better developed, and policies related to the integration of the internet and agriculture are generally implemented first in the eastern regions. In contrast, the western regions of China are economically underdeveloped, and internet penetration and infrastructure are far behind the eastern regions. At the same time, farmers in these regions have fewer opportunities for education and internet knowledge, making their agricultural activity enthusiasm more significantly

negatively impacted by the digital divide.

4.5. Mediation Mechanism Test

To further explore how the digital divide hinders farmers' enthusiasm for agricultural activities, this section conducts a mediation mechanism test. The goal is to better understand how the digital divide operates and to propose optimization suggestions. The specific analysis is presented in **Table 6**.

Part (**A**) of **Table 6** represents the mediation mechanism test results for information collection willingness. In Part (**A**) of **Table 6**, (1)–(3) correspond to the mediation test for the impact of the digital access divide on farmers' enthusiasm for agricultural activities; (4)–(6) correspond to the mediation test for the impact of the digital usage divide; and (7)–(9) correspond to the mediation test for the impact of the digital outcome divide.

The regression results indicate that the digital outcome divide significantly affects information collection costs at the 1% level. Moreover, after introducing the mediation variable, the significant coefficient of the digital outcome divide's impact on farmers' enthusiasm for agricultural activities increases further. This suggests that the digital outcome divide negatively affects farmers' enthusiasm for agricultural activities by reducing their willingness to collect information. Therefore, Hypothesis H2 is supported.

Similarly, Part (**B**) represents the mediation mechanism test results for risk preference. As shown in Part (**B**) of **Table 6**, in (4)–(6), the regression results indicate that the digital usage divide has a significant negative impact on risk preference at the 1% level. Additionally, after introducing the mediation variable, the impact of the digital divide on farmers' enthusiasm for agricultural activities remains significantly negative.

This suggests that the digital usage divide may influence farmers' risk preference, making them more inclined toward high-risk, high-reward jobs or activities. As a result, their enthusiasm for agricultural activities decreases. Therefore, Hypothesis H3 is supported.

In Part (**C**), the mediation mechanism test for the digital access divide is shown in (1)–(3), while the mediation mechanism test for the digital outcome divide is presented in (6)–(9). The mediation effect test results for both variables are significant.

A possible explanation is that the existence of the digital access divide restricts farmers' access to information, leading to an overly confident perception of their socioeconomic status. This, in turn, reduces their willingness to engage in agricultural activities, ultimately decreasing their enthusiasm for agricultural work.

Regarding the mediation test for the digital outcome divide, the internet exposes farmers to higher social classes, making them feel pessimistic about their own socioeconomic status. This reduces their overall motivation for life and work, ultimately leading to a decline in their enthusiasm for agricultural activities. Therefore, Hypothesis H4 is supported.

In summary, an in-depth analysis of how the digital divide hinders farmers' enthusiasm for agricultural activities reveals that: The digital access divide primarily reduces farmers' enthusiasm for agricultural activities by increasing their class perception. The digital usage divide affects farmers' enthusiasm mainly by increasing their risk preference. The digital outcome divide hinders agricultural enthusiasm by lowering farmers' willingness to collect information and their perception of social class.

Table 6. Mediation Mechanism Test.

(A) Information Collection Willingness									
Var	farmers' agricultural motivation	Information Collection Willingness	farmers' agricultural motivation	farmers' agricultural motivation	Information Collection Willingness	farmers' agricultural motivation	farmers' agricultural motivation	Information Collection Willingness	farmers' agricultural motivation
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Digital divide in access	-7877.5** (-2.39)	-4.274 (-0.31)	-7850.6** (-2.39)						

Table 6. *Cont.*

(A) Information Collection Willingness									
Var	farmers' agricultural motivation	Information Collection Willingness	farmers' agricultural motivation	farmers' agricultural motivation	Information Collection Willingness	farmers' agricultural motivation	farmers' agricultural motivation	Information Collection Willingness	farmers' agricultural motivation
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Digital divide in usage				-14458.2*** (-3.23)	-25.07 (-1.56)	-14314.2*** (-3.20)			
Digital divide in outcome							-3686.3*** (-2.62)	-16.78*** (-3.34)	-3598.1** (-2.55)
Cnt	3080	3080	3080	2007	2007	2007	2007	2007	2007
(B) Risk Preference									
Var	farmers' agricultural motivation	Risk Preference	farmers' agricultural motivation	farmers' agricultural motivation	Risk Preference	farmers' agricultural motivation	farmers' agricultural motivation	Risk Preference	farmers' agricultural motivation
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Digital divide in access	-7877.5** (-2.39)	0.000837 (0.03)	-7861.3** (-2.42)						
Digital divide in usage				-14458.2*** (-3.23)	0.0719** (2.23)	-12841.0*** (-2.90)			
Digital divide in outcome							-3686.3*** (-2.62)	-0.00976 (-0.96)	-3911.9*** (-2.82)
Cnt	3080	2007	2007	3080	2007	2007	3080	2007	2007
R^2	0.338	0.133	0.577	0.341	0.414	0.861	0.322	0.385	0.860
(C) Class Perception									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Var	farmers' agricultural motivation	Class Perception	farmers' agricultural motivation	farmers' agricultural motivation	Class Perception	farmers' agricultural motivation	farmers' agricultural motivation	Class Perception	farmers' agricultural motivation
Digital divide in access	-7877.5** (-2.39)	0.141** (2.44)	-6673.9** (-2.05)						
Digital divide in usage				-14458.2*** (-3.23)	0.0289 (0.46)	-14523.8*** (-3.25)			
Digital divide in outcome							-3686.3*** (-2.62)	-0.0689*** (-3.53)	-3555.9** (-2.52)
Cnt	3080	2007	2007	3080	2007	2007	3080	2007	2007
R^2	0.338	0.096	0.556	0.341	0.061	0.351	0.322	0.075	0.330

Notes: *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively;
The t-statistic is shown in parentheses;
Control variables have been included in the regression.

5. Discussion

In recent years, the digital divide has become increasingly pronounced in China, driven by disparities in the speed and coverage of Internet development. It has gradually expanded from the initial access divide to include the usage divide and, more recently, the outcome divide. With the rapid development of digital technologies, the widespread application of the digital economy and Internet technologies has brought significant benefits to both the economy and society. It has not only greatly improved the efficiency of production activities, but also reduced the cost of information acquisition and expanded the scope and depth of individual interactions with the outside world [40]. However, while some individuals benefit from the advantages of the "digital dividend," many others are adversely affected by the unequal development of digital technologies. In particular, rural residents, the elderly, and those living in economically underdeveloped western regions of China face more severe digital divides. These disparities not only hinder their access to education, employment, and daily services but also constrain the broader development potential of their regions [2–4]. Therefore, the digital divide has become a critical issue that must be addressed during the development of the digital economy and social progress. It is both necessary and important to study this problem. However, existing research rarely focuses on how the digital divide affects farmers' agricultural motivation in developing countries. This area remains largely overlooked. In the long run, the negative effects of the digital divide may lead to more social and economic problems. Moreover, most current studies emphasize farmers' income levels, while ignoring the deeper psychological impact—whether farmers are willing to make additional efforts beyond basic agricultural inputs. As a result, researchers and policymakers often lack direct evidence on how the digital divide influences farmers' motivation to engage in agriculture.

This study focuses on rural residents in China, a group especially vulnerable to the digital divide. It explores how the digital divide affects their agricultural motivation, along with the underlying mechanisms and heterogeneity of the impact. The findings have important value in addressing this issue. First, the study uses an OLS model and a series of robustness tests. The results clearly show that the digital divide negatively affects rural residents' motivation to engage in agriculture. This has important policy implications. It suggests that digital inequality may slow down individual economic growth in rural areas. In turn, this could hinder regional development. Over time, it may also affect the national goals of building a "Digital China" and strengthening agriculture [25]. As a result, when making digital policies, policymakers may start to include rural residents—the "digitally disadvantaged"—in broader development plans. This is important for narrowing the digital divide in the long run. It can also reduce the negative effects on rural residents' employment, education, and social environment. In addition, this study helps local policymakers understand the mechanisms through which the digital divide affects agricultural motivation. These include changes in information-seeking behavior, risk preferences, and perceived social status. This allows policies to be more targeted and efficient, unlike traditional, broad, and low-efficiency approaches. For example, improving internet access in rural areas, offering digital skills training, and encouraging the use of digital tools in agriculture can all help boost motivation. In the long term, such efforts may promote the development of digital agriculture [41].

Although this study has made efforts to ensure methodological completeness and the reliability of its findings, some limitations remain.

First, the study uses data from the 2022 China Family Panel Studies (CFPS). This ensures the timeliness of the data. However, it cannot reflect the long-term impact of the digital divide on farmers' agricultural engagement. Future research could consider using multi-year data to explore long-term trends. Second, the issue of endogeneity. This study attempts to address endogeneity and reverse causality by including as many control variables as possible and by using instrumental variable methods. However, endogeneity may still exist. Future studies could add more control variables or adopt better instruments to reduce its effect. Third, the sample of this study is rural residents in China. Due to differences in digital development and social conditions across countries, the findings may not be generalizable to other con-

texts. Future research could expand the sample or conduct cross-country comparisons to improve external validity.In conclusion, although some limitations remain, the current methods and empirical analyses provide robust evidence on the impact, mechanisms, and heterogeneity of the digital divide on farmers' agricultural engagement. This study holds both academic and policy value.

6. Conclusions

This study uses the data from the 2022 China Family Panel Studies (CFPS2022) survey. An OLS model is employed to explore the impact of the digital divide on the agricultural engagement of rural residents in China. Specifically, it examines the effects of the three levels of the digital divide: access divide, usage divide, and outcome divide. Based on the baseline test, the study further conducts robustness tests, endogeneity tests, and other analyses to ensure the reliability of the results. Additionally, the study explores the differences in the impact mechanisms and effects of the three levels of the digital divide on farmers' agricultural behavior. It includes a series of further analyses, such as heterogeneity tests and mechanism tests. The research findings will be presented below based on these tests.

First, the baseline test results indicate that the digital divide has a significant negative impact on the agricultural engagement of rural residents in China. Second, both the access divide, usage divide, and outcome divide each have an adverse effect on agricultural engagement to varying degrees. What's more, the study conducts robustness checks by replacing the dependent variable, removing extreme values, and substituting control variables to verify the reliability of the research conclusions. The results show that regardless of whether the dependent variable is replaced, extreme values are excluded, or control variables are substituted, the conclusion remains consistent. The different levels of the digital divide continue to have a significant negative impact on the agricultural engagement of rural residents. To avoid the impact of endogeneity issues on the research conclusions, this study uses the average digital divide experienced by respondents of the same age in the same province as an instrumental variable. The validity of the instrumental variable was ensured through weak instrument and instrument validity tests, guaranteeing the reasonableness of the chosen instrumental variable. Building on this, the study conducted an endogeneity test using the instrumental variable method. The results show that, even after considering the endogeneity issue, the baseline conclusions remain robust. In the heterogeneity analysis, the study conducted subgroup research based on different age groups, genders, and regions of rural residents. The findings indicate that older farmers are more susceptible to the impact of the digital divide compared to younger farmers. Among male farmers, the access and usage divides of the digital divide have a more significant impact, while for female farmers, the negative effects of the usage and outcome divides are more pronounced. Compared to farmers in the eastern region, rural residents in non-eastern regions are more likely to experience negative impacts on their agricultural behavior due to the digital divide. Additionally, to explore the mechanisms through which the three levels of the digital divide affect the agricultural behavior of rural residents in China, this study conducted a mechanism test using a stepwise regression approach to examine whether the mediating variables play a role. The results show that the access divide primarily affects farmers' agricultural behavior by increasing their perception of social class, thus lowering their agricultural engagement. The usage divide mainly operates by increasing farmers' risk preference. Meanwhile, the outcome divide exerts its mediating effect by reducing information collection willingness and perception of social class.

6.1. Policy Recommendations

This study has significant international policy implications. Currently, there is a notable digital divide between developing and developed countries, as well as within developing countries themselves. This issue is particularly evident among digital vulnerable groups, such as rural residents. The adverse impact of the digital divide on rural residents is both comprehensive and profound, and its negative effect on their agricultural engagement can lead to serious consequences. It impacts not only individual rural residents but also the economic development and social stability of the regions they in-

habit in developing countries. Furthermore, it could lead to a series of issues, including unemployment, inflation, and other related problems. This study provides an in-depth analysis of the impact and mechanisms of the digital divide on the agricultural engagement of farmers in developing countries. The findings of this research offer policy recommendations that can help mitigate the adverse effects of the digital divide in other developing countries. Moreover, the outcomes of this study can encourage international policymakers to offer more attention and benefits to digital vulnerable groups, such as farmers. Therefore, this research also holds significant humanitarian value at the international level.

Based on the research findings, this study offers the following recommendations. First, in developing countries such as China, policymakers should create practical and feasible policies to ensure that while internet technology develops rapidly, residents in underdeveloped areas (such as rural regions) can also benefit from the digital dividend. This will help reduce the adverse effects brought about by the digital divide [42]. For example, actively promoting the improvement of internet coverage in rural areas is essential. Specifically, efforts should be made to increase investments in infrastructure construction in rural and remote areas, including power supply, communication network base stations, and equipment upgrades, to ensure stable internet access [11]. Second, local governments in rural areas should actively formulate policies related to reducing internet access costs. This can be done by providing subsidies to operators, offering free installation of equipment, and implementing fee reductions, in order to encourage rural residents to access and use the internet and digital technologies [39]. Third, policymakers should regularly conduct digital technology training programs and actively encourage rural residents to integrate internet technologies into agricultural production activities.

Fourth, efforts should be made to strengthen training on preventing internet misinformation. Additionally, rural residents' ability to identify digital misinformation should be enhanced through methods such as bulletin boards, leaflets, and public announcements [43]. Fifth, as the digital divide affects farmers' risk preferences, it is essential to actively lower the threshold for agricultural credit or improve financial accessibility [44,45]. This will create conditions for increasing the income levels of rural residents, ultimately driving the growth of their agricultural engagement [41].

6.2. Research Prospects

This study examines the impact of the digital divide on agricultural engagement among rural residents. It also conducts a series of in-depth analyses based on this. Furthermore, it proposes several feasible recommendations for policymakers to mitigate the negative effects of the digital divide. With the continuous development of the Internet, the digital divide has become increasingly severe. At present, the issue has evolved into a three-level digital divide. Each level has different causes and impacts, indicating that the digital divide will become more layered in the future, with more complex origins and consequences. In addition, the digital divide has a wide-ranging negative impact on farmers. It not only affects them economically, but also exerts adverse effects on social, ideological, and psychological levels. Therefore, this issue deserves serious attention. Due to the complexity and multi-layered nature of the digital divide, research on this issue should keep pace with the times and maintain timeliness. In the future, researchers should conduct more in-depth and comprehensive studies in line with the evolving characteristics of digital technology and the layered development of the digital divide. This will help ensure that timely and targeted recommendations can be proposed to address the emerging challenges.

Author Contributions

Conceptualization, Y.D.; methodology, Y.D.; formal analysis, Y.D.; resources, Y.A.; data curation, X.L.; writing—original draft preparation, F.Z.; writing—review and editing, F.Z.; supervision, F.Z.; funding acquisition, Y.A. All authors have read and agreed to the published version of the manuscript.

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Institutional Review Board Statement

The study was conducted in accordance with the Declaration of Helsinki, and approved by the Institutional Review Board (or Ethics Committee) of Peking University Biomedical Committee (protocol code IRB00001052-14010).

Informed Consent Statement

Informed consent was obtained from all subjects involved in the study.

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Data Availability

The data for this study originate from the China Family Panel Studies (CFPS2022) conducted by the Peking University Institute of Social Science Survey in 2022.

Conflict of Interest

The authors declare no conflict of interest.

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